

SAO Special Report No. 126

SATELLITE ORBITAL DATA

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## ORBITAL INFORMATION<sup>1</sup>

The orbital elements have been derived by the indicated staff members of the Satellite Tracking Program, Smithsonian Astrophysical Observatory, employing the SAO Differential Orbit Improvement Program (DOI).

Field-reduced photographs from SAO Baker-Nunn cameras comprise the majority of observations used in computing these orbital data. SAO Moonwatch teams, the NASA Minitrack network, foreign observatories, miscellaneous U.S. and foreign observers, and various radar installations also contribute valuable observations.

As opposed to osculating elements, the elements presented here are mean elements in the sense that the effects of the short period perturbations due to the earth's oblateness have been eliminated.

SAO mean elements have been derived from observations covering several days, and are given in the form of a table. The successive sets of elements are essentially independent of each other. They are dependent, however, in the sense that high-order coefficients in the secular and the long-periodic terms are generally considered as known and as constant for periods of several weeks or months, as dictated by convenience.

The times of epoch in the mean elements are reckoned in Julian Days, but for the sake of convenience the number 2400000.5 has been subtracted to provide an abbreviated notation which we call "Modified Julian Days," or "MJD."

The units of the orbital elements are degrees for angular quantities, megameters ( $Mm = 10^6$  meters) for linear quantities, and revolutions for the mean anomaly  $M$  and its derivatives.

The tabulated values of the SAO mean elements give the values of argument of perigee  $\omega$ , right ascension of the ascending node  $\Omega$ , inclination  $i$ , eccentricity  $e$ , and mean anomaly  $M$  as functions of time  $t = T - T_0$  (where  $T_0$  is the reference epoch) expressed in days. The single digit placed at the right of each value represents the standard error for that element and refers to the last digit given.

The same tabulation also gives the mean (anomalistic) motion  $n$ , the orbital acceleration  $n'/2$  or  $n'$  ( $dn/dt$ ), and the semimajor axis  $a$  or the geocentric distance of perigee  $q$  (in megameters). Of the last three columns, the one headed  $N$  indicates the number of observations used for the computation of a set of elements; the one headed  $D$ , the number of days used; and the one headed  $\sigma$ , the standard error of the representation of the observations relative to their assumed accuracy.

SAO smoothed elements have been derived from observations covering about two weeks or more. They are given as functions of time and generally include both secular and periodic terms. The general expression for any element  $E$  is

$$E = E_0 + E_1 t + E_2 t^2 + \dots + \sum A_i \sin(B_i + C_i t)$$

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<sup>1</sup>

This work was supported in part by grant NsG 87-60 from the National Aeronautics and Space Administration.

where  $t = T - T_0$  is again expressed in days. The presence of a standard error associated with a particular coefficient indicates that this quantity was determined by the process of differential orbit improvement; the absence of a standard error means that the quantity was taken from some other source.

In our computer program, the inclination and the argument of perigee are referred to the true equator of date, the right ascension of the ascending node, however, is reckoned from the mean equinox of 1950.0 along the corresponding mean equator to the intersection with the moving true equator of date, and then along the true equator of date. To transform from right ascension of the node as determined by the DOI to right ascension of the node referred to the mean equinox of date, one uses

$$\Omega^\circ = \Omega^\circ(\text{DOI}) + 3^\circ 508 \times 10^{-5} (\text{MJD} - 33281) ,$$

where MJD stands for the Modified Julian Day of the date.

The mean (anomalistic) motion  $n$  can be obtained from the smoothed elements by differentiating the expression for  $M$ , and the orbital acceleration  $n'$  can be obtained by twice differentiating the same expression for  $M$ .

The sun-perigee data are related to the perturbing effects of atmospheric drag. From left to right, are the Modified Julian Day (MJD); the perigee height  $Z$  (in kilometers) above the International Ellipsoid of Reference; the geocentric latitude of the perigee ( $\varphi$ ); the angular geocentric distance ( $\psi$ ) from the perigee of the sun; and the difference in right ascension (D.R.A.) between the perigee and the sun; all these angles are expressed in degrees. In the last column we give the rate of change of the period ( $\dot{P}$ ) expressed in days per day.

Satellite 1958 Alpha (Explorer I)

Beatrice Miller

## I. SAO smoothed elements

The following elements are based on 66 observations and are valid for the period October 1 through October 16, 1962.

$$T_o = 37946.0 \text{ MJD}$$

$$\omega = (329^{\circ}73 \pm 1) + (7^{\circ}537 \pm 3)t + .0007588t^2 + .3041 \cos \Omega$$

$$\Omega = (165^{\circ}482 \pm 5) - (5^{\circ}049 \pm 1)t - .0001198t^2 + .0032 \cos \omega$$

$$i = (33^{\circ}202 \pm 1) - .0001143t + .816 \times 10^{-5}t^2 - .0041 \sin \omega$$

$$e = (.09156 \pm 3) + .2453 \times 10^{-4}t - .1088 \times 10^{-5}t^2 + .0004972 \sin \omega$$

$$M = (.44911 \pm 4) + (13.537807 \pm 7)t + (.0001548 \pm 6)t^2 + (.194 \pm 7) \times 10^{-5}t^3 \\ - (.68 \pm 13) \times 10^{-7}t^4 - .0008704 \cos \omega$$

Standard error of one observation:  $\sigma = \pm 2.28$ ,

The following elements are based on 82 observations and are valid for the period October 16 through November 1, 1962.

$$T_o = 37961.0 \text{ MJD}$$

$$\omega = (82^{\circ}93 \pm 2) + (7^{\circ}528 \pm 3)t + .0007588t^2 + .3041 \cos \Omega$$

$$\Omega = (89^{\circ}704 \pm 5) - (5^{\circ}0537 \pm 9)t - .0001198t^2 + .0032 \cos \omega$$

$$i = (33^{\circ}203 \pm 2) + .0001305t + .816 \times 10^{-5}t^2 - .0041 \sin \omega$$

$$e = (.09119 \pm 3) - .811 \times 10^{-5}t - .1088 \times 10^{-5}t^2 + .0004972 \sin \omega$$

$$M = (.05371 \pm 6) + (13.642974 \pm 8)t + (.0001898 \pm 8)t^2 + (.119 \pm 5) \times 10^{-5}t^3 \\ - (.11 \pm 1) \times 10^{-6}t^4 - .0008704 \cos \omega$$

Standard error of one observation:  $\sigma = \pm 2.90$ ,

The following elements are based on 55 observations and are valid for the period November 1 through November 15, 1962.

$$T_o = 37976.0 \text{ MJD}$$

$$\omega = (196^\circ 09 \pm 2) + (7^\circ 559 \pm 4)t + .0007588t^2 + .3041 \cos \omega$$

$$\Omega = (13^\circ 882 \pm 4) - (5^\circ 0570 \pm 8)t - .0001198t^2 + .0032 \cos \omega$$

$$i = (33^\circ 2068 \pm 9) + .0003753t + .816 \times 10^{-5}t^2 - .0041 \sin \omega$$

$$e = (.09090 \pm 2) - .4075 \times 10^{-4}t - .1088 \times 10^{-5}t^2 + .0004972 \sin \omega$$

$$M = (.74072 \pm 5) + (13.64871 \pm 1)t + (.0002096 \pm 7)t^2 - (.159 \pm 4) \times 10^{-5}t^3 \\ - (.31 \pm 1) \times 10^{-6}t^4 - .0008704 \cos \omega$$

Standard error of one observation:  $\sigma = \pm 1.40$ .

The following elements are based on 70 observations and are valid for the period November 15 through December 1, 1962.

$$T_o = 37991.0 \text{ MJD}$$

$$\omega = (309^\circ 50 \pm 4) + (7^\circ 575 \pm 7)t + .000848t^2 + .3144 \cos \omega$$

$$\Omega = (297^\circ 999 \pm 7) - (5^\circ 062 \pm 2)t - .000142t^2 + .0031 \cos \omega$$

$$i = (33^\circ 206 \pm 2) - .0005777t + .1482 \times 10^{-4}t^2 - .0039 \sin \omega$$

$$e = (.09079 \pm 3) + .673 \times 10^{-5}t - .413 \times 10^{-6}t^2 + .0004980 \sin \omega$$

$$M = (.5127 \pm 1) + (13.65433 \pm 2)t + (.0002059 \pm 8)t^2 - (.31 \pm 74) \times 10^{-7}t^3 \\ - (.17 \pm 1) \times 10^{-6}t^4 - .0008998 \cos \omega$$

Standard error of one observation:  $\sigma = \pm 3.28$ .

The following elements are based on 46 observations and are valid for the period December 1 through December 16, 1962.

$$T_o = 38006.0 \text{ MJD}$$

$$\omega = (62^\circ 88 \pm 1) + (7^\circ 564 \pm 3)t + .000848t^2 + .3144 \cos \omega$$

$$\Omega = (222^\circ 041 \pm 4) - (5^\circ 0647 \pm 9)t - .000142t^2 + .0031 \cos \omega$$

$$i = (33^\circ 204 \pm 1) - .0001331t + .1482 \times 10^{-4}t^2 - .0039 \sin \omega$$

$$e = (.09053 \pm 3) - .566 \times 10^{-5}t - .413 \times 10^{-6}t^2 + .0004980 \sin \omega$$

$$M = (.37106 \pm 4) + (13.659907 \pm 8)t + (.0001736 \pm 6)t^2 - (.24 \pm 6) \times 10^{-6}t^3 \\ + (.46 \pm 13) \times 10^{-7}t^4 - .0008998 \cos \omega$$

Standard error of one observation:  $\sigma = \pm 1.63$ .

The following elements are based on 48 observations and are valid for the period December 16, 1962 through January 1, 1963.

$$T_o = 38022.0 \text{ MJD}$$

$$\omega = (183^\circ 95 \pm 2) + (7^\circ 577 \pm 3)t + .000848t^2 + .3144 \cos \omega$$

$$\Omega = (140^\circ 943 \pm 4) - (5^\circ 0724 \pm 8)t - .000142t^2 + .0031 \cos \omega$$

$$i = (33^\circ 202 \pm 1) + .0003412t + .1482 \times 10^{-4} t^2 - .0039 \sin \omega$$

$$e = (.09023 \pm 4) - .1887 \times 10^{-4} t - .413 \times 10^{-6} t^2 + .0004980 \sin \omega$$

$$M = (.97606 \pm 5) + (13.665896 \pm 9)t + (.0001716 \pm 6)t^2 - (.331 \pm 4) \times 10^{-5} t^3 \\ + (.39 \pm 9) \times 10^{-7} t^4 - .0008998 \cos \omega$$

Standard error of one observation:  $\sigma = \pm 1.55$ .

## II. SAO mean elements - Satellite 1958 Alpha

3 October - 30 December 1962

T (MJD)	$\omega$	$\Omega$	i	e	M	$\Delta$	$n^{1/2}$	q	N	D	$\sigma$
37940.0	284.586 7	195.765 4	33.2059 9	.09111 2	.62718 2	13.636182 1	.1265E-3 7	6.725004	46	8	.47
37944.0	314.787 6	175.577 6	33.201 1	.09126 3	.17383 3	13.637215 2	.128E-3 1	6.723517	34	8	.80
37948.0	345.12 2	155.388 8	33.204 2	.09130 5	.72443 5	13.638506 3	.162E-3 1	6.722841	22	8	.71
37952.0	15.31 1	135.186 3	33.202 1	.09150 3	.28084 4	13.639910 1	.1735E-3 4	6.720902	24	8	.40
37956.0	45.34 2	114.980 3	33.199 1	.09178 4	.86330 6	13.641317 2	.1671E-3 8	6.718387	27	8	.48
37960.0	75.44 2	94.755 5	33.196 1	.09173 4	.41095 7	13.642684 2	.167E-3 1	6.718265	25	8	.45
37964.0	105.47 1	74.544 3	33.198 1	.09163 2	.98446 4	13.644220 2	.2049E-3 7	6.718494	45	8	.60
37968.0	135.482 9	54.324 3	33.2014 9	.09145 1	.56455 3	13.645705 1	.1698E-3 5	6.719375	54	8	.51
37972.0	165.59 2	34.106 6	33.205 2	.09112 3	.15005 6	13.647097 2	.1907E-3 9	6.721320	47	8	.89
37976.0	195.85 4	13.89 1	33.209 2	.09080 6	.7414 1	13.648652 3	.196E-3 1	6.723226	38	8	1.13
37980.0	226.19 4	353.64 1	33.215 3	.09066 4	.3390 1	13.650044 3	.171E-3 1	6.723756	17	8	.55
37984.0	256.45 4	333.420 5	33.211 3	.09046 2	.9423 1	13.651475 3	.199E-3 1	6.724792	21	8	.65
37988.0	286.85 3	313.187 5	33.212 3	.09025 2	.55144 9	13.653012 3	.188E-3 1	6.725792	30	8	.74
37992.0	317.28 3	292.94 1	33.211 4	.09021 3	.1667 1	13.654802 3	.209E-3 1	6.725515	31	8	1.01
37996.0	347.60 2	272.692 8	33.208 2	.09052 3	.78886 7	13.656393 2	.1752E-3 9	6.722689	34	8	.83
38000.0	17.83 2	252.424 6	33.204 2	.09071 3	.41713 6	13.657863 2	.178E-3 1	6.720829	27	8	.66
38004.0	47.97 2	232.172 5	33.201 2	.09093 5	.05130 8	13.659343 2	.180E-3 1	6.718703	25	8	.74
38008.0	78.06 2	211.913 5	33.199 2	.09101 5	.69145 8	13.660778 2	.1717E-3 8	6.717659	28	8	.64
38012.0	108.18 1	191.642 8	33.198 3	.09096 6	.33710 5	13.662166 4	.178E-3 1	6.717587	20	8	.61
38016.0	138.38 6	171.37 2	33.200 7	.0908 1	.9882 2	13.663574 5	.196E-3 2	6.718053	18	8	1.69
38020.0	168.60 6	151.08 2	33.200 5	.0904 1	.6455 2	13.665139 6	.201E-3 3	6.720381	19	8	1.78
38024.0	198.84 2	130.789 5	33.205 2	.09004 5	.30934 8	13.666473 2	.1499E-3 9	6.722982	24	8	.70
38028.0	229.26 2	110.505 3	33.208 1	.08979 4	.97743 6	13.6667524 2	.127E-3 1	6.724452	31	8	.50

Table 1

## RELATIVE POSITIONS OF THE SUN AND THE PERIGEE OF SATELLITE 1958 ALPHA

MJD	Z	$\varphi$	$\psi$	D.R.A.	$\dot{P}$
PERIGEE IN SUNLIGHT					
37940.	353.	-32.0	67.4	294.5	-0.136E-05
37944.	348.	-22.9	57.4	303.3	-0.138E-05
37948.	345.	-8.1	52.5	307.0	-0.174E-05
37952.	343.	8.3	53.9	308.5	-0.187E-05
37956.	343.	22.9	57.2	312.0	-0.180E-05
37960.	345.	32.0	57.4	320.5	-0.179E-05
37964.	346.	31.8	51.9	332.0	-0.220E-05
37968.	344.	22.6	41.3	340.1	-0.182E-05
37972.	343.	7.8	28.3	343.3	-0.205E-05
37976.	345.	-8.6	16.9	344.6	-0.210E-05
37980.	349.	-23.3	12.6	348.1	-0.184E-05
37984.	352.	-32.2	13.9	356.6	-0.214E-05
37988.	353.	-31.6	14.1	8.2	-0.202E-05
37992.	350.	-21.8	15.1	16.1	-0.224E-05
37996.	345.	-6.8	23.3	18.9	-0.188E-05
38000.	343.	9.7	37.0	19.8	-0.191E-05
38004.	344.	24.0	51.5	23.1	-0.193E-05
38008.	345.	32.4	62.8	31.4	-0.184E-05
38012.	345.	31.3	67.9	42.3	-0.191E-05
38016.	343.	21.3	65.8	49.5	-0.210E-05
38020.	342.	6.2	58.7	51.9	-0.215E-05
38024.	345.	-10.2	51.8	52.6	-0.161E-05
38028.	350.	-24.5	51.0	56.2	-0.136E-05

Satellite 1959 Alpha 1 (Vanguard II)

Maria Gutierrez

I. SAO smoothed elements

The following elements are based on 208 observations and are valid for the period September 30 through October 31, 1962.

$$T_o = 37952.0 \text{ MJD}$$

$$\omega = (349^\circ 313 \pm 5) + (5^\circ 2884 \pm 4)t + .23 \times 10^{-4}t^2 + .1523 \cos \omega$$

$$\Omega = (170^\circ 378 \pm 2) - (3^\circ 5194 \pm 2)t + .3 \times 10^{-5}t^2 + .0077 \cos \omega$$

$$i = (32^\circ 8758 \pm 5) - .0069 \sin \omega$$

$$e = (.16415 \pm 1) + .12 \times 10^{-4}t + .000457 \sin \omega$$

$$M = (.54177 \pm 2) + (11.477913 \pm 1)t + (.283 \pm 3) \times 10^{-5}t^2 + (.30 \pm 3) \times 10^{-7}t^3 \\ - .000439 \cos \omega$$

Standard error of one observation:  $\sigma = \pm 1.15$ .

The following elements are based on 220 observations and are valid for the period October 31 through November 30, 1962.

$$T_o = 37984.0 \text{ MJD}$$

$$\omega = (158^\circ 605 \pm 7) + (5^\circ 2953 \pm 6)t + .23 \times 10^{-4}t^2 + .1523 \cos \omega$$

$$\Omega = (57^\circ 754 \pm 2) - (3^\circ 5185 \pm 2)t + .3 \times 10^{-5}t^2 + .0077 \cos \omega$$

$$i = (32^\circ 8815 \pm 7) - .0069 \sin \omega$$

$$e = (.16419 \pm 1) - .166 \times 10^{-4}t + .000457 \sin \omega$$

$$M = (.83818 \pm 2) + (11.478103 \pm 2)t + (.356 \pm 3) \times 10^{-5}t^2 - (.73 \pm 31) \times 10^{-8}t^3 \\ - .000439 \cos \omega$$

Standard error of one observation:  $\sigma = \pm 1.38$ .

The following elements are based on 249 observations and are valid for the period November 30 through December 31, 1962.

$$T_o = 38014.0 \text{ MJD}$$

$$\omega = (317^\circ 354 \pm 7) + (5^\circ 2914 \pm 7)t + .000294t^2 + .1523 \cos \omega$$

$$\Omega = (312^\circ 194 \pm 2) - (3^\circ 5195 \pm 2)t - .35 \times 10^{-4} t^2 + .0077 \cos \omega$$

$$i = (32^\circ 8813 \pm 6) - .0069 \sin \omega$$

$$e = (.164038 \pm 7) - .141 \times 10^{-4} t + .000457 \sin \omega$$

$$M = (.18483 \pm 2) + (11.478340 \pm 2)t + (.542 \pm 2) \times 10^{-5} t^2 + (.03 \pm 24) \times 10^{-8} t^3$$

$$- .000439 \cos \omega$$

Standard error of one observation:  $\sigma = \pm 1^\circ 30$ .

## II. SAO mean elements - Satellite 1959 Alpha 1

1 October - 28 December 1962

T (MTD)	$\omega$	$\Omega$	i	e	M	n	$n^{1/2}$	q	N	D	$\sigma$
37938.0	275.225 6	219.635 4	32.884 1	.16389 3	.85167 2	11.47783 1	.15E-5 5	6.939858	47	8	.39
37942.0	296.440 9	205.560 4	32.882 1	.16388 3	.76293 3	11.47781 1	.12E-5 5	6.939895	46	8	.39
37946.0	317.65 1	191.487 4	32.880 1	.16394 3	.67425 4	11.47787 3	.2E-5 1	6.939448	40	8	.42
37950.0	338.84 1	177.412 3	32.8778 9	.16406 3	.58569 4	11.47788 2	.30E-5 5	6.938450	49	8	.43
37954.0	.00 1	163.344 3	32.8759 9	.16423 2	.49731 3	11.47793 1	.33E-5 5	6.937003	58	8	.41
37958.0	21.15 1	149.269 3	32.874 1	.16441 2	.40906 4	11.47793 2	.40E-5 8	6.935484	57	8	.44
37962.0	42.33 1	135.189 3	32.871 1	.16453 2	.32083 4	11.47797 2	.12E-5 7	6.934434	64	8	.49
37966.0	63.460 9	121.114 3	32.870 1	.16461 2	.23284 3	11.47806 2	.34E-5 6	6.9333796	62	8	.41
37970.0	84.551 8	107.030 3	32.867 1	.16465 2	.14512 3	11.47807 1	.30E-5 5	6.933450	64	8	.38
37974.0	105.676 8	92.945 3	32.868 1	.16460 2	.05738 3	11.47807 2	.37E-5 7	6.933860	61	8	.47
37978.0	126.788 9	78.858 3	32.871 1	.16423 2	.96980 3	11.47813 1	.28E-5 5	6.934428	55	8	.43
37982.0	147.90 1	64.782 3	32.877 1	.16438 2	.88230 3	11.47811 2	.41E-5 5	6.93554	51	8	.40
37986.0	169.04 1	50.712 4	32.881 1	.16418 2	.79481 4	11.47815 2	.36E-5 6	6.937289	48	8	.43
37990.0	190.21 1	36.631 4	32.885 1	.16405 2	.70742 4	11.47815 2	.41E-5 6	6.938387	57	8	.42
37994.0	211.42 1	22.553 4	32.889 1	.16392 1	.62002 4	11.47814 2	.27E-5 5	6.939490	65	8	.41
37998.0	232.61 2	8.484 3	32.892 1	.163770 8	.53275 3	11.47818 1	.29E-5 4	6.940694	65	8	.35
38002.0	253.82 1	354.419 2	32.889 1	.163681 7	.44552 4	11.47817 2	.29E-5 5	6.941438	64	8	.35
38006.0	275.05 2	340.346 2	32.887 2	.16367 1	.35833 5	11.47824 2	.32E-5 6	6.941507	52	8	.38
38010.0	296.24 1	326.270 4	32.886 2	.16371 1	.27139 4	11.47827 2	.61E-5 7	6.941165	53	8	.41
38014.0	317.45 1	312.196 4	32.885 1	.16378 1	.18453 3	11.47827 2	.60E-5 6	6.940590	74	8	.44
38018.0	338.68 1	298.121 4	32.882 8	.16392 2	.09778 3	11.47835 1	.57E-5 4	6.939419	72	8	.42
38022.0	359.86 1	284.046 4	32.8795 8	.16408 2	.01131 3	11.47842 1	.49E-5 4	6.937999	62	8	.39
38026.0	21.020 9	269.971 3	32.8765 8	.16423 2	.92503 3	11.47845 1	.43E-5 4	6.936764	59	8	.40

Table 2

RELATIVE POSITIONS OF THE SUN AND THE PERIGEE OF SATELLITE 1959 ALPHA

MJD	Z	$\phi$	$\psi$	D.R.A.	P
PERIGEE IN SUNLIGHT					
37938.	568.	-32.7	56.1	309.1	-0.228E-07
37942.	567.	-29.1	48.5	315.8	-0.182E-07
37946.	564.	-21.5	41.6	320.0	-0.304E-07
37950.	561.	-11.3	37.9	321.7	-0.455E-07
37954.	559.	-0.	39.0	321.9	-0.501E-07
37958.	558.	11.3	43.5	322.1	-0.607E-07
37962.	559.	21.4	48.8	323.6	-0.182E-07
37966.	560.	29.0	52.6	327.6	-0.516E-07
37970.	561.	32.7	53.4	333.9	-0.455E-07
37974.	561.	31.5	50.7	340.8	-0.562E-07
37978.	560.	25.8	44.9	345.9	-0.425E-07
37982.	559.	16.8	36.7	348.3	-0.622E-07
37986.	559.	5.9	27.4	348.6	-0.546E-07
37990.	560.	-5.5	18.4	348.2	-0.622E-07
37994.	563.	-16.4	11.7	348.5	-0.410E-07
37998.	566.	-25.6	9.4	350.7	-0.440E-07
38002.	569.	-31.4	10.1	355.5	-0.440E-07
38006.	569.	-32.7	10.3	2.2	-0.486E-07
38010.	568.	-29.1	9.5	8.1	-0.926E-07
38014.	565.	-21.5	10.9	11.6	-0.911E-07
38018.	562.	-11.4	17.0	12.6	-0.865E-07
38022.	560.	-0.1	26.1	12.1	-0.744E-07
38026.	559.	11.2	36.4	11.6	-0.653E-07

Satellite 1959 Eta (Vanguard III)

Maria Gutierrez

I. SAO smoothed elements

The following elements are based on 111 observations and are valid for the period September 30 through October 31, 1962.

$$T_o = 37952.0 \text{ MJD}$$

$$\omega = (218^\circ 820 \pm 7) + (4^\circ 8976 \pm 7)t - .000196t^2 + .1287 \cos \omega$$

$$\Omega = (148^\circ 699 \pm 4) - (3^\circ 2869 \pm 4)t - .6 \times 10^{-5}t^2 + .0090 \cos \omega$$

$$i = (33^\circ 356 \pm 1) + .2 \times 10^{-4}t - .0077 \sin \omega$$

$$e = (.188684 \pm 7) + .87 \times 10^{-5}t + .000452 \sin \omega$$

$$M = (.55832 \pm 2) + (11.088167 \pm 2)t + (.326 \pm 3) \times 10^{-5}t^2 - (.19 \pm 3) \times 10^{-7}t^3 \\ - .000374 \cos \omega$$

Standard error of one observation:  $\sigma = \pm 1.65$ .

The following elements are based on 97 observations and are valid for the period October 31 through November 30, 1962.

$$T_o = 37984.0 \text{ MJD}$$

$$\omega = (15^\circ 448 \pm 7) + (4^\circ 8923 \pm 7)t - .000196t^2 + .1287 \cos \omega$$

$$\Omega = (43^\circ 510 \pm 3) - (3^\circ 2868 \pm 3)t - .6 \times 10^{-5}t^2 + .0090 \cos \omega$$

$$i = (33^\circ 361 \pm 1) + .2 \times 10^{-4}t - .0077 \sin \omega$$

$$e = (.188671 \pm 8) + .87 \times 10^{-5}t + .000452 \sin \omega$$

$$M = (.38264 \pm 2) + (11.088365 \pm 2)t + (.325 \pm 3) \times 10^{-5}t^2 - (.70 \pm 4) \times 10^{-7}t^3 \\ - .000374 \cos \omega$$

Standard error of one observation:  $\sigma = \pm 1.50$ .

The following elements are based on 124 observations and are valid for the period November 30 through December 31, 1962.

$$T_o = 38014.0 \text{ MJD}$$

$$\omega = (162^\circ 238 \pm 7) + (4^\circ 8908 \pm 6)t + .000203t^2 + .1287 \cos \omega$$

$$\Omega = (304^\circ 907 \pm 3) - (3^\circ 2879 \pm 3)t + .3 \times 10^{-5} t^2 + .0090 \cos \omega$$

$$i = (33^\circ 360 \pm 1) - .2 \times 10^{-4} t - .0077 \sin \omega$$

$$e = (.18879 \pm 1) - .89 \times 10^{-5} t + .000452 \sin \omega$$

$$M = (.03511 \pm 2) + (11.088492 \pm 2)t + (.92 \pm 3) \times 10^{-6} t^2 - (.89 \pm 4) \times 10^{-7} t^3 \\ - .000374 \cos \omega$$

Standard error of one observation:  $\sigma = \pm 1^\circ 65$ .

T (MJD)	$\omega$	$\Omega$	i	e	M	n	$n'/2$	q	N	D	$\sigma$
37938.0	150.16 1	194.712 9	33.352 1	*18896 2	*32494 3	11.088024 3	*6E-5 1	6.888727	26	6	.59
37942.0	169.73 2	181.57 1	33.355 2	*18872 2	*67724 4	11.088072 3	*6E-5 2	6.890710	25	6	.77
37946.0	189.30 1	168.413 6	33.359 1	*18858 1	*02980 3	11.088109 2	-.1E-5 2	6.891842	25	6	.48
37950.0	208.90 2	155.261 9	33.362 3	*18842 2	*38238 3	11.088128 2	*3E-5 2	6.893213	18	6	.59
37954.0	228.53 1	142.118 8	33.363 3	*18834 2	*73494 3	11.088138 2	*3E-5 1	6.893947	24	6	.62
37958.0	248.12 1	128.978 5	33.361 3	*18832 1	*08764 3	11.088150 2	*1E-5 1	6.894088	18	6	.47
37962.0	267.76 1	115.830 3	33.360 2	*18829 1	*44031 3	11.088177 2	*3E-5 2	6.894325	22	6	.53
37966.0	287.39 1	102.682 5	33.359 3	*18832 1	*79314 3	11.088205 2	*1E-5 1	6.894021	21	6	.54
37970.0	306.94 1	89.527 6	33.358 3	*18837 1	*14621 3	11.088231 2	*23E-5 9	6.893641	26	5	.55
37974.0	326.57 1	76.378 5	33.360 2	*18844 1	*49918 2	11.088269 2	*4E-5 1	6.893014	29	6	.46
37978.0	346.19 1	63.229 6	33.361 1	*18855 9	*85229 3	11.088307 1	*2E-5 1	6.891907	23	6	.37
37982.0	5.80 1	50.080 7	33.360 1	*18872 1	*20554 3	11.088354 2	*3E-5 1	6.890620	18	6	.44
37986.0	25.34 2	36.936 9	33.359 2	*18883 1	*55909 4	11.088397 2	*2E-5 2	6.889659	18	6	.47
37990.0	44.90 2	23.80 1	33.357 3	*18898 2	*91266 3	11.088421 2	-.1E-5 1	6.888392	17	6	.49
37994.0	64.5 2	10.65 3	33.351	*18875	*26628 2	11.088439 3	-.1E-5 2	6.890386	16	6	.65
37998.0	83.95 1	357.498 4	33.356 4	*18916 2	*62007 3	11.088447 2	*1E-5 9	6.886814	16	6	.57
38002.0	103.49 2	344.344 6	33.362 8	*18914 3	*97382 6	11.088464 4	*1E-5 3	6.886957	17	6	.89
38006.0	122.99 2	331.207 7	33.365 7	*18909 3	*32765 5	11.088492 4	*3E-5 2	6.887348	14	6	.42
38010.0	142.61 3	318.04 1	33.344 7	*18894	*68132 1	11.088519 3	*3E-5 2	6.889320	18	6	.45
38014.0	162.11 1	304.90 1	33.357 4	*18887 3	*03544 3	11.088506 3	*2E-5 2	6.889248	35	6	.47
38018.0	181.70 1	291.737 7	33.358 2	*18872 2	*38944 2	11.088497 1	-.6E-6 7	6.890519	36	6	.43
38022.0	201.31 2	278.578 9	33.362 2	*18864 3	*74332 3	11.088473 1	-.2E-5 1	6.891227	29	6	.49
38026.0	220.883 9	265.446 6	33.365 1	*18849 2	*09721 2	11.088451 2	-.1E-5 9	6.892495	27	6	.47

Table 3

## RELATIVE POSITIONS OF THE SUN AND THE PERIGEE OF SATELLITE 1959 ETA

MJD	Z	$\phi$	$\psi$	D.R.A.	$\dot{P}$
PERIGEE IN EARTH SHADOW					
37938.	512.	15.9	158.3	162.4	-0.976E-07
37942.	513.	5.6	162.6	162.6	-0.976E-07
37946.	514.	-5.1	159.0	162.2	0.163E-07
37950.	516.	-15.4	151.1	162.3	-0.488E-07
37954.	519.	-24.3	143.2	164.1	-0.488E-07
37958.	521.	-30.7	137.3	168.1	-0.163E-07
37962.	522.	-33.3	134.5	174.2	-0.488E-07
37966.	522.	-31.7	135.1	180.4	-0.163E-07
37970.	519.	-26.1	139.1	184.8	-0.374E-07
37974.	517.	-17.6	145.9	186.9	-0.651E-07
37978.	514.	-7.5	154.6	187.0	-0.325E-07
37982.	512.	3.2	163.9	186.2	-0.488E-07
37986.	512.	13.6	172.3	185.7	-0.325E-07
37990.	513.	22.8	173.2	186.6	0.163E-07
37994.	517.	29.7	167.5	189.7	0.163E-07
37998.	515.	33.1	162.5	194.8	-0.163E-07
38002.	515.	32.3	159.1	200.6	-0.163E-07
38006.	514.	27.5	157.0	204.9	-0.488E-07
38010.	513.	19.5	154.7	206.9	-0.488E-07
38014.	511.	9.7	151.0	206.8	-0.325E-07
38018.	512.	-0.9	145.1	205.7	0.976E-08
38022.	514.	-11.5	137.5	204.8	0.325E-07
38026.	517.	-21.1	129.3	205.0	0.163E-07

Satellite 1959 Iota 1 (Explorer VII)

Maria Gutierrez

I. SAO smoothed elements

The following elements are based on 82 observations and are valid for the period September 30 through October 31, 1962.

$$T_o = 37952.0 \text{ MJD}$$

$$\omega = (187^\circ 81 \pm 2) + (3^\circ 400 \pm 2)t - .000748t^2 + 1^\circ 2489 \cos \omega$$

$$\Omega = (234^\circ 716 \pm 2) - (4^\circ 1907 \pm 2)t - .5 \times 10^{-5} t^2 + .0053 \cos \omega$$

$$i = (50^\circ 309 \pm 1) - .0014 \sin \omega$$

$$e = (.03631 \pm 2) + .99 \times 10^{-5} t + .000789 \sin \omega$$

$$M = (.67871 \pm 6) + (14.233796 \pm 6)t + (.380 \pm 3) \times 10^{-5} t^2 + (.39 \pm 4) \times 10^{-7} t^3 \\ - .0031294 \cos \omega$$

Standard error of one observation:  $\sigma = \pm 1^\circ 75$ .

The following elements are based on 83 observations and are valid for the period October 31 through November 30, 1962.

$$T_o = 37984.0 \text{ MJD}$$

$$\omega = (296^\circ 63 \pm 3) + (3^\circ 419 \pm 3)t - .000748t^2 + 1^\circ 2489 \cos \omega$$

$$\Omega = (100^\circ 619 \pm 2) - (4^\circ 1913 \pm 2)t - .5 \times 10^{-5} t^2 + .0053 \cos \omega$$

$$i = (50^\circ 308 \pm 2) - .0014 \sin \omega$$

$$e = (.03612 \pm 2) + .99 \times 10^{-5} t + .000789 \cos \omega$$

$$M = (.16216 \pm 8) + (14.233890 \pm 9)t + (.500 \pm 5) \times 10^{-5} t^2 - (.19 \pm 6) \times 10^{-7} t^3 \\ - .0031294 \cos \omega$$

Standard error of one observation:  $\sigma = \pm 2^\circ 63$ .

The following elements are based on 98 observations and are valid for the period November 30 through December 31, 1962.

$$T_o = 38014.0 \text{ MJD}$$

$$\omega = (39^\circ 52 \pm 2) + (3^\circ 283 \pm 2)t - .000748t^2 + 1^\circ 2489 \cos \omega$$

$$\Omega = (334^\circ 895 \pm 1) - (4^\circ 1904 \pm 3)t - .5 \times 10^{-5}t^2 + .0053 \cos \omega$$

$$i = (50^\circ 312 \pm 2) - .0014 \sin \omega$$

$$e = (.03619 \pm 2) + .99 \times 10^{-5}t + .000789 \sin \omega$$

$$M = (.18237 \pm 5) + (14.234147 \pm 6)t + (.250 \pm 4) \times 10^{-5}t^2 + (.70 \pm 4) \times 10^{-7}t^3 \\ - .0031294 \cos \omega$$

Standard error of one observation:  $\sigma = \pm 1.95$ .

## II. SAO mean elements - Satellite 1959 Iota 1

1 October - 28 December 1962

$\Omega$ (MJD)	$\omega$	$\Omega$	1	e	M	n	$n'/2$	q	N	D	$\sigma$
37938.0	139.20 2	293.311 2	.03667 2	.40838 4	14.23385 1	.44E-5 5	6.928112	30 8	.52		
37942.0	152.61 3	276.620 2	.03652 3	.34389 8	14.23386 3	.54E-5 8	6.929180	25 8	.65		
37946.0	166.14 5	259.852 4	.03641 3	.2792 2	14.23380 3	.2E-5 1	6.929944	18 8	.52		
37950.0	179.73 4	243.087 8	.03622 2	.2144 1	14.23376 5	.1E-5 1	6.931378	18 8	.55		
37954.0	193.56 5	226.356 9	.03605 2	.1489 2	14.23353 5	-.1E-5 1	6.932623	18 8	.41		
37958.0	207.14 9	209.59 1	.03581 3	.0841 3	14.23369 7	.79E-5 8	6.934293	21 8	.29		
37962.0	220.6 2	192.84 5	.0364 6	.0202 8	14.23380 2	.61E-5 8	6.930068	20 8	.41		
37966.0	234.8 1	176.05 2	.0354 1	.9538 4	14.23362 8	.38E-5 7	6.937382	23 8	.46		
37970.0	248.66 5	159.278 3	.03533 3	.8885 1	14.233858 2	-.3E-6 5	6.937749	24 8	.55		
37974.0	262.58 5	142.524 2	.03536 1	.8232 1	14.233861 2	.9E-6 8	6.937520	18 8	.61		
37978.0	276.54 6	125.763 2	.03536 1	.7578 2	14.233883 2	.61E-5 8	6.937460	19 8	.68		
37982.0	290.50 5	108.998 2	.03514 2	.6925 2	14.233944 2	.95E-5 8	6.937225	21 8	.73		
37986.0	304.19 9	92.236 9	.03510 6	.6282 3	14.234030 2	.68E-5 8	6.939930	20 8	.47		
37990.0	318.19 6	75.461 8	.0299 3	.5630 2	14.234096 3	.3E-5 1	6.935140	23 8	.79		
37994.0	331.90 6	58.719 8	.0302 3	.4986 2	14.234140 3	.1E-5 1	6.934536	26 8	.80		
37998.0	345.75 3	41.956 5	.0303 4	.43395 8	14.233906 1	.20E-5 6	6.933614	24 8	.48		
38002.0	359.45 4	25.190 5	.0307 4	.3697 1	14.233983 1	.66E-5 7	6.932008	27 8	.69		
38006.0	12.91 2	8.428 2	.0309 2	.30636 2	14.234101 1	.103E-4 5	6.936212	37 8	.46		
38010.0	26.41 2	351.664 1	.0307 2	.03655 2	.24285 7	.72E-5 5	6.928850	34 8	.50		
38014.0	39.93 4	334.897 3	.0307 3	.03663 3	.1796 1	.45E-5 6	6.928196	18 8	.68		
38018.0	53.34 3	318.128 4	.0306 4	.03676 3	.1167 1	.40E-5 8	6.926242	16 8	.64		
38022.0	66.63 5	301.373 9	.0309 7	.03696 3	.0542 1	.4E-5 1	6.925811	20 8	.59		
38026.0	80.2 1	284.593 9	.0298 7	.03706 6	.9910 3	.45E-5 8	6.925045	21 8	.47		

Table 4

RELATIVE POSITIONS OF THE SUN AND THE PERIGEE OF SATELLITE 1959 IOTA 1

MJD	Z	$\varphi$	$\psi$	D.R.A.	$\dot{P}$
PERIGEE IN SUNLIGHT					
37938.	555.	30.2	102.1	257.7	-0.434E-07
37942.	553.	20.7	112.2	247.9	-0.533E-07
PERIGEE IN EARTH SHADOW					
37946.	552.	10.6	123.6	236.9	-0.197E-07
37950.	553.	0.2	134.3	225.2	-0.987E-08
37954.	555.	-10.4	141.3	213.7	0.987E-08
37958.	559.	-20.5	141.9	202.6	-0.780E-07
37962.	557.	-30.0	136.4	192.6	-0.502E-07
37966.	567.	-39.0	127.6	185.4	-0.375E-07
37970.	570.	-45.8	119.7	181.1	0.296E-08
37974.	572.	-49.7	114.5	180.4	-0.888E-08
37978.	572.	-49.9	113.2	181.3	-0.602E-07
37982.	570.	-45.1	115.8	180.6	-0.938E-07
37986.	570.	-39.5	121.3	176.2	-0.671E-07
37990.	562.	-30.9	128.0	168.7	-0.296E-07
37994.	559.	-21.2	133.1	158.7	-0.987E-08
37998.	558.	-10.9	134.3	147.2	-0.197E-07
38002.	554.	-0.4	130.7	135.0	-0.652E-07
38006.	558.	9.9	123.8	122.6	-0.102E-06
38010.	553.	20.0	116.1	110.7	-0.71E-07
PERIGEE IN SUNLIGHT					
38014.	553.	29.6	109.5	100.0	-0.444E-07
38018.	557.	38.1	105.2	91.3	-0.395E-07
38022.	558.	44.9	103.3	85.4	-0.395E-07
38026.	559.	49.3	103.2	83.2	-0.444E-07

Satellite 1960 Gamma 2 (Transit 1B)

Rajendra C. Nigam

I. SAO smoothed elements

The following elements are based on 32 observations and are valid for the period April 13 through April 30, 1960.

$$T_o = 37045.0 \text{ MJD}$$

$$\omega = (287^\circ 86 \pm 9) + (3^\circ 62 \pm 2)t - .002470t^2 + 1^\circ 8444 \cos \omega$$

$$\Omega = (242^\circ 540 \pm 6) - (4^\circ 647 \pm 1)t - .000188t^2 + .0028 \cos \omega$$

$$i = (51^\circ 301 \pm 5) - .0001037t - .0011 \sin \omega$$

$$e = (.02824 \pm 4) + .2957 \times 10^{-4}t + .000865 \sin \omega$$

$$M = (.9572 \pm 2) + (15.02190 \pm 5)t + (.1711 \pm 4) \times 10^{-3}t^2 + (.77 \pm 12) \times 10^{-6}t^3 \\ - .004011 \cos \omega$$

Standard error of one observation:  $\sigma = \pm 2.83$ .

The following elements are based on 183 observations and are valid for the period April 30 through May 16, 1960.

$$T_o = 37061.0 \text{ MJD}$$

$$\omega = (344^\circ 33 \pm 6) + (3^\circ 57 \pm 1)t - .00227t^2 + 1^\circ 8444 \cos \omega$$

$$\Omega = (168^\circ 159 \pm 3) - (4^\circ 6520 \pm 4)t - .000131t^2 + .0028 \cos \omega$$

$$i = (51^\circ 285 \pm 1) + .0004997t - .0011 \sin \omega$$

$$e = (.02755 \pm 2) + .297 \times 10^{-4}t + .000865 \sin \omega$$

$$M = (.3553 \pm 2) + (15.02730 \pm 3)t + (.1856 \pm 8) \times 10^{-3}t^2 + (.39 \pm 2) \times 10^{-5}t^3 \\ - (.50 \pm 12) \times 10^{-7}t^4 - .004011 \cos \omega$$

Standard error of one observation:  $\sigma = \pm 2.88$ .

The following elements are based on 91 observations and are valid for the period May 16 through May 30, 1960.

$$\begin{aligned}T_0 &= 37077.0 \text{ MJD} \\ \omega &= (41^\circ 09' \pm 8) + (3^\circ 55' \pm 2)t - .00227t^2 + 1^\circ 8444 \cos \omega \\ \Omega &= (93^\circ 689 \pm 3) - (4^\circ 6570 \pm 8)t - .000131t^2 + .0028 \cos \omega \\ i &= (51^\circ 294 \pm 2) + .00050t - .0011 \sin \omega \\ e &= (.02765 \pm 4) + .297 \times 10^{-4}t + .000865 \sin \omega \\ M &= (.8488 \pm 2) + (15.03436 \pm 5)t + (.211 \pm 1) \times 10^{-3}t^2 + (.13 \pm 8) \times 10^{-6}t^3 \\ &\quad + (.62 \pm 23) \times 10^{-7}t^4 - .004011 \cos \omega\end{aligned}$$

Standard error of one observation:  $\sigma = \pm 3.10$ .

The following elements are based on 35 observations and are valid for the period September 29 through October 23, 1962.

$$\begin{aligned}T_0 &= 37948.0 \text{ MJD} \\ \omega &= (316^\circ 5 \pm 2) + (3^\circ 69 \pm 2)t + .0090t^2 + 2^\circ 5507 \cos \omega \\ \Omega &= (281^\circ 433 \pm 8) - (4^\circ 813 \pm 2)t + .00026t^2 + .0037 \cos \omega \\ i &= (51^\circ 239 \pm 7) - .00077 \sin \omega \\ e &= (.02006 \pm 4) - .6 \times 10^{-4}t + .000864 \sin \omega \\ M &= (.5832 \pm 5) + (15.24123 \pm 4)t + (.109 \pm 8) \times 10^{-3}t^2 + (.150 \pm 3) \times 10^{-5}t^3 \\ &\quad - .006221 \cos \omega\end{aligned}$$

Standard error of one observation:  $\sigma = \pm 4.35$ .

## II. SAO mean elements - Satellite 1960 Gamma 2

16 April - 12 May 1960

T (MD)	$\omega$	$\Omega$	i	e	M	n	$n'/2$	q	N	D	$\sigma$
37040.0	269.78 5	265.770 2	51.296 2	•02681 3	•8512 2	15.01993 4	•174E-3 9	6.752636	17 10	.51	
37041.0	273.32 8	261.126 4	51.291 4	•02687 4	•8721 2	15.020557 5	•197E-3 2	6.752030	25 10	.39	
37042.0	276.99 8	256.479 4	51.293 3	•02691 4	•8929 2	15.020934 5	•186E-3 2	6.751653	27 10	1.17	
37043.0	280.81 9	251.837 5	51.302 4	•02728 5	•9137 2	15.021205 8	•168E-3 2	6.749063	29 10	1.36	
37044.0	284.48 9	247.191 5	51.302 4	•02731 5	•9351 2	15.02154 1	•1693E-3 8	6.748740	29 10	1.36	
37045.0	288.37 4	242.542 3	51.302 2	•02728 3	•9563 1	15.021821 7	•1698E-3 3	6.748838	26 10	.60	
37046.0	291.86 1	237.893 2	51.297 1	•02715 2	•9786 2 4	15.022252 3	•1724E-3 3	6.749634	25 10	.55	
37047.0	295.5 2	238.25 2	51.30 2	•0271 3	•0012 7	15.022573 6	•174E-3 1	6.749702	25 10	2.19	
37048.0	299.1 1	228.60 1	51.30 1	•0271 2	•0240 4	15.022927 3	•198E-3 3	6.749688	23 10	1.35	
37049.0	302.8 1	223.95 2	51.30 1	•0272 2	•0471 5	15.023313 5	•189E-3 2	6.749319	24 10	1.35	
37050.0	306.4 1	219.30 1	51.298 8	•0271 2	•0707 3	15.023690 7	•1843E-3 9	6.749437	25 10	1.08	
37051.0	310.0 1	214.65 1	51.298 9	•0272 2	•0946 4	15.024052 7	•1779E-3 6	6.748997	25 10	1.08	
37052.0	313.59 8	209.995 9	51.295 7	•0271 1	•1189 3	15.024357 8	•177E-3 1	6.749407	21 10	.83	
37053.0	317.37 8	205.351 4	51.301 3	•02719 4	•1430 2	15.024728 5	•1722E-3 4	6.748581	36 10	.78	
37054.0	320.97 5	200.704 1	51.303 1	•02723 2	•1681 2	15.025088 3	•1628E-3 3	6.748208	35 10	.69	
37055.0	324.69 9	196.051 3	51.298 2	•02725 5	•1929 3	15.025393 5	•1645E-3 5	6.747999	46 10	1.45	
37056.0	328.4 1	191.403 4	51.293 4	•02721 6	•2183 4	15.02569 1	•1618E-3 9	6.748145	57 10	1.85	
37057.0	331.7 1	186.757 5	51.289 5	•02724 5	•2453 3	15.02591 1	•1591E-3 8	6.747859	63 10	1.67	
37058.0	335.21 6	182.124 5	51.274 5	•02734 3	•2716 2	15.026247 7	•150E-3 1	6.747087	69 10	1.32	
37059.0	338.85 5	177.460 2	51.287 2	•02738 3	•2979 1	15.026570 5	•1615E-3 9	6.746698	97 10	1.41	
37060.0	342.41 3	172.809 2	51.287 2	•02743 3	•32469 9	15.026912 5	•169E-3 1	6.746301	128 10	1.29	
37061.0	345.98 3	168.156 2	51.289 1	•02746 2	•35182 7	15.027266 3	•1803E-3 8	6.745981	148 10	1.13	
37062.0	349.62 3	163.505 2	51.289 2	•02748 2	•37913 7	15.027632 2	•197E-3 1	6.745683	174 10	1.25	
37063.0	353.19 2	158.852 2	51.290 2	•02750 2	•40697 7	15.028038 2	•2072E-3 7	6.745454	188 10	1.26	
37064.0	356.75 2	154.203 2	51.290 1	•02766 2	•43523 6	15.028463 2	•2199E-3 5	6.744208	182 10	1.16	
37065.0	*36 3	149.550 2	51.290 2	•02766 2	•46381 7	15.028914 2	•2259E-3 3	6.744102	196 10	1.31	
37066.0	3.94 3	144.896 2	51.291 1	•02768 2	•49294 7	15.029382 2	•2310E-3 3	6.743798	203 10	1.35	

III. SAO mean elements - Satellite 1960 Gamma 2

13-31 May 1960;  
3-21 October 1962

$\frac{T}{(MD)}$	$\omega$	$\Omega$	$i$	$e$	$M$	$n$	$n^{1/2}$	$q$	$N$	$D$	$\sigma$
37067.0	7.53 2	140.241 2	51.292 1	.02768 2	.52249 7	15.029849 2	.2346E-3 2	6.743648	205 10	1.41	
37068.0	11.04 3	135.589 2	51.291 1	.02775 2	.55270 7	15.030348 2	.2379E-3 2	6.743063	192 10	1.38	
37069.0	14.40 3	130.934 2	51.293 2	.02782 2	.58385 8	15.030847 2	.2390E-3 3	6.742390	197 10	1.53	
37070.0	17.98 2	126.284 2	51.292 1	.02789 2	.61483 6	15.031328 2	.2364E-3 2	6.741774	185 10	1.20	
37071.0	21.53 2	121.630 2	51.293 1	.02793 2	.64637 7	15.031794 2	.2315E-3 2	6.741317	184 10	1.21	
37072.0	25.11 3	116.976 2	51.294 1	.02798 2	.67831 7	15.032254 2	.2264E-3 3	6.740879	182 10	1.21	
37073.0	28.64 3	112.321 2	51.293 1	.02802 2	.71080 8	15.032702 2	.2214E-3 4	6.740436	174 10	1.20	
37074.0	32.11 3	107.666 2	51.294 1	.02804 2	.74389 8	15.033141 2	.2127E-3 6	6.740166	145 10	1.10	
37075.0	35.69 3	103.008 2	51.294 1	.02808 2	.7771 1	15.033566 3	.2150E-3 6	6.749806	129 10	1.35	
37076.0	49.11 5	98.351 2	51.293 2	.02806 3	.8112 2	15.033983 3	.2122E-3 2	6.739796	108 15	1.28	
37077.0	42.56 7	93.693 2	51.291 2	.02810 4	.8455 2	15.034396 3	.2139E-3 2	6.739384	89 15	1.16	
37078.0	45.96 7	89.036 3	51.291 2	.02809 4	.8805 2	15.034816 4	.2140E-3 3	6.739338	84 15	1.20	
37079.0	49.41 7	84.380 3	51.292 2	.02811 4	.9157 2	15.035242 3	.2122E-3 3	6.739070	86 15	1.23	
37080.0	52.93 7	79.724 3	51.293 2	.02814 4	.9511 2	15.035675 3	.2161E-3 5	6.738750	81 15	1.24	
37081.0	56.39 8	75.069 3	51.294 2	.02813 5	.9871 2	15.036111 3	.2169E-3 7	6.738675	72 14	1.25	
37082.0	59.65 8	70.409 3	51.292 2	.02824 4	.0241 2	15.036537 3	.2193E-3 8	6.737769	60 12	.95	
37083.0	63.16 9	65.751 4	51.293 2	.02619 5	.0608 2	15.036969 4	.222E-3 1	6.737985	54 12	.98	
37084.0	66.78 7	61.102 8	51.290 5	.02807 5	.0977 2	15.037426 5	.2200E-3 3	6.738665	50 15	.79	
37085.0	70.35 6	56.451 3	51.286 3	.02809 3	.1351 2	15.037857 5	.2198E-3 3	6.738405	46 15	.92	
37940.0	287.9 1	319.92 2	51.22 1	.01923 6	.6589 3	15.239054 5	.105E-3 2	6.739858	11 8	1.14	
37942.0	295.6 1	310.29 2	51.23 1	.01920 8	.1374 4	15.239456 5	.95E-4 3	6.739969	12 8	1.28	
37944.0	303.3 2	300.66 2	51.25 1	.0194 1	.6166 6	15.239872 7	.103E-3 4	6.738456	11 8	2.07	
37946.0	311.0 1	291.051 7	51.248 4	.01952 4	.0965 3	15.24031 1	.115E-3 4	6.737474	7 8	.58	
37948.0	318.60 7	281.437 4	51.245 3	.01941 3	.5778 2	15.240880 3	.147E-3 1	6.738060	9 8	.54	
37952.0	333.3 3	262.20 1	51.24 2	.0202 1	.545 1	15.24209 2	.162E-3 6	6.732485	11 8	2.64	
37954.0	340.9 2	252.582 8	51.245 8	.02005 5	.0302 4	15.242719 5	.159E-3 2	6.733169	15 8	1.48	
37958.0	355.5 5	233.359 9	51.258 8	.0202 2	.006 2	15.243962 3	.162E-3 1	6.731675	14 8	.72	

Table 5

RELATIVE POSITIONS OF THE SUN AND THE PERIGEE OF SATELLITE 1960 GAMMA 2

MJD	Z	$\Phi$	$\Psi$	D.R.A.	$\dot{P}$
PERIGEE IN EARTH SHADOW					
37040.	387.	-51.3	132.5	151.3	-0.154E-05
37041.	387.	-51.2	133.0	151.4	-0.175E-05
37042.	386.	-50.8	133.7	151.6	-0.165E-05
37043.	383.	-50.0	134.7	151.9	-0.149E-05
37044.	383.	-49.1	135.7	151.8	-0.150E-05
37045.	382.	-47.8	136.9	151.7	-0.150E-05
37046.	383.	-46.4	137.8	150.9	-0.153E-05
37047.	382.	-44.8	138.8	149.9	-0.154E-05
37048.	381.	-43.0	139.5	148.7	-0.175E-05
37049.	380.	-41.0	140.1	147.3	-0.167E-05
37050.	380.	-38.9	140.4	145.5	-0.163E-05
37051.	378.	-36.7	140.2	143.6	-0.158E-05
37052.	378.	-34.4	139.7	141.3	-0.157E-05
37053.	376.	-31.9	138.9	139.1	-0.153E-05
37054.	375.	-29.4	137.4	136.6	-0.147E-05
37055.	374.	-26.8	135.7	134.0	-0.146E-05
37056.	373.	-24.1	133.5	131.2	-0.143E-05
37057.	372.	-21.7	130.6	128.0	-0.141E-05
37058.	371.	-19.1	127.6	124.9	-0.133E-05
37059.	370.	-16.4	124.4	121.8	-0.143E-05
37060.	369.	-13.6	120.8	118.6	-0.150E-05
37061.	368.	-10.9	117.2	115.3	-0.160E-05
37062.	368.	-8.1	113.3	112.0	-0.174E-05
37063.	367.	-5.3	109.4	108.7	-0.183E-05

Table 5 (cont.)

## RELATIVE POSITIONS OF THE SUN AND THE PERIGEE OF SATELLITE 1960 GAMMA 2

MJD	Z	$\Phi$	$\Psi$	D.R.A.	$\dot{P}$
PERIGEE IN SUNLIGHT					
37064.	366.	-2.5	105.3	105.3	-0.195E-05
37065.	366.	0.3	101.2	101.9	-0.200E-05
37066.	365.	3.1	97.1	98.5	-0.205E-05
37067.	365.	5.9	93.0	95.1	-0.208E-05
37068.	365.	8.6	88.9	91.7	-0.211E-05
37069.	365.	11.2	84.8	88.3	-0.212E-05
37070.	365.	13.9	80.8	85.0	-0.209E-05
37071.	365.	16.6	77.0	81.7	-0.205E-05
37072.	365.	19.3	73.3	78.5	-0.200E-05
37073.	365.	22.0	69.8	75.4	-0.196E-05
37074.	365.	24.5	66.4	72.3	-0.191E-05
37075.	366.	27.1	63.2	69.4	-0.190E-05
37076.	369.	36.2	66.7	75.4	-0.190E-05
37077.	367.	31.9	57.6	63.8	-0.189E-05
37078.	368.	34.1	55.1	61.2	-0.189E-05
37079.	368.	36.3	53.0	58.7	-0.190E-05
37080.	369.	38.5	51.4	56.4	-0.191E-05
37081.	369.	40.5	49.7	54.1	-0.192E-05
37082.	369.	42.3	48.3	52.5	-0.194E-05
37083.	370.	44.1	47.4	50.9	-0.196E-05
37084.	371.	45.8	46.9	49.8	-0.195E-05
37085.	372.	47.3	46.5	48.9	-0.194E-05

Table 5 (cont.)

RELATIVE POSITIONS OF THE SUN AND THE PERIGEE OF SATELLITE 1960 GAMMA 2

MJD	Z	$\Phi$	$\Psi$	D.R.A.	P
PERIGEE IN SUNLIGHT					
37940.	373.	-47.9	73.1	68.6	-0.904E-06
37942.	372.	-44.7	70.9	67.3	-0.818E-06
37944.	369.	-40.7	67.6	64.9	-0.887E-06
37946.	367.	-36.1	63.4	61.3	-0.990E-06
37948.	365.	-31.0	58.1	56.7	-0.127E-05
37952.	357.	-20.5	45.3	45.2	-0.139E-05
37954.	356.	-14.8	38.5	38.9	-0.137E-05
37958.	353.	-3.5	26.1	25.4	-0.139E-05

$\Omega$ (MD)	$\omega$	$\Omega$	i	e	M	n	$n^{1/2}$	q	N	D	$\sigma$
37938.0	271.06 3	288.435 2	47.295 2	.06235 2	*78967 9	12.441571 5	*279E-3 9	7.376196	48	2	.049
37939.0	274.79 4	-85.163 2	47.297 2	.06252 2	*2318 1	12.442108 6	*21E-3 1	7.374693	57	2	.043
37940.0	278.56 4	281.895 2	47.297 1	.06269 2	*6743 1	12.442614 6	*25E-3 1	7.373162	62	2	.042
37941.0	282.29 4	278.627 2	47.301 1	.06282 2	*1174 1	12.443071 4	*213E-3 8	7.371923	49	2	.041
37942.0	286.00 4	275.355 2	47.304 2	.06295 2	*5610 1	12.443476 7	*19E-3 1	7.370729	49	2	.044
37943.0	289.83 4	272.092 2	47.300 2	.06303 2	*0046 1	12.443923 7	*205E-3 1	7.369983	44	2	.049
37944.0	293.58 4	268.923 2	47.299 2	.06310 1	*4189 1	12.444345 6	*24E-3 1	7.369247	45	2	.049
37945.0	297.37 4	265.557 2	47.296 2	.06319 1	*8935 1	12.444786 5	*21E-3 1	7.368332	62	2	.049
37946.0	301.06 5	262.294 3	47.299 2	.06324 2	*3888 1	12.45274 8	*25E-3 1	7.367729	57	2	.046
37947.0	304.88 5	259.026 4	47.297 3	.06333 2	*7842 1	12.445729 8	*23E-3 2	7.366880	37	2	.053
37948.0	308.62 5	255.747 6	47.294 3	.06336 2	*2303 1	12.44624 1	*23E-3 2	7.366447	34	2	.049
37949.0	312.41 7	252.477 8	47.298 4	.06350 3	*6767 2	12.44671 2	*25E-3 2	7.365119	27	2	.056
37950.0	316.16 4	249.210 5	47.291 2	.06333 1	*1238 1	12.447275 7	*27E-3 1	7.366266	17	2	.046
37951.0	320.09 8	245.955 8	47.289 5	.06341 2	*5708 2	12.44780 1	*31E-3 2	7.365440	22	2	.057
37952.0	324.03 7	242.696 8	47.286 3	.06346 3	*0184 2	12.448333 9	*27E-3 2	7.364799	31	2	.052
37953.0	327.75 5	239.390 6	47.285 3	.06343 2	*6572 1	12.44893 1	*29E-3 2	7.364864	34	2	.056
37954.0	331.56 5	236.115 5	47.281 3	.06358 2	*9162 1	12.449487 8	*31E-3 2	7.363392	30	2	.056
37955.0	335.26 6	232.851 7	47.284 2	.06361 2	*3661 2	12.45013 1	*32E-3 2	7.362980	34	2	.055
37956.0	339.11 5	229.573 6	47.285 1	.06357 2	*8163 1	12.450722 9	*29E-3 2	7.362986	30	2	.056
37957.0	343.10 3	226.286 3	47.273 2	.06366 1	*2666 1	:2.451351 7	*31E-3 1	7.362031	32	2	.044
37958.0	346.92 4	223.009 4	47.271 2	.06377 1	*7180 1	12.451973 7	*29E-3 1	7.360948	33	2	.044
37959.0	350.81 9	219.626 8	47.264 4	.06390 2	*1698 2	12.452584 2	*32E-3 4	7.359558	22	2	.050
37960.0	354.73 5	216.439 5	47.268 2	.06405 2	*6222 2	12.453298 8	*33E-3 2	7.358269	22	2	.050
37961.0	358.44 5	213.156 5	47.270 2	.06416 2	*0758 1	12.453967 9	*22E-3 2	7.357139	28	2	.052
37962.0	2.20 4	209.887 5	47.276 2	.06433 2	*5299 1	12.454673 9	*36E-3 2	7.355508	33	2	.058
37963.0	6.03 4	206.608 4	47.276 2	.06447 2	*9847 1	12.455475 7	*41E-3 1	7.354085	30	2	.045
37964.0	9.91 5	203.314 5	47.276 2	.06476 3	*4400 1	12.456258 8	*39E-3 1	7.351469	21	2	.045
37965.0	13.71 6	200.037 6	47.280 2	.06495 3	*8963 2	12.457010 9	*39E-3 2	7.349718	30	2	.066
37966.0	17.47 6	196.761 6	47.282 2	.06515 3	*3535 2	12.457768 9	*37E-3 2	7.347807	33	2	.069
37967.0	21.33 4	193.471 5	47.281 2	.06539 2	*8111 1	12.459441 8	*30E-3 1	7.345654	26	2	.046
37968.0	24.97 3	190.189 4	47.284 2	.06558 2	*2700 1	12.459225 6	*41E-3 1	7.343870	33	2	.047

$\Psi$ (MJD)	$\omega$	$\Omega$	$i$	$e$	$M$	$n$	$n^{1/2}$	$q$	$N$	$D$	$\sigma$
37969.0	28.80 5	186.89 5	47.292 3	.06599 3	7291 1	12.459914 9	.31E-3 2	7.340395	.37	2	.65
37970.0	32.44 6	183.62 5	47.292 3	.06622 3	1894 2	12.460619 8	.35E-3 2	7.338286	40	2	.79
37971.0	36.19 5	180.332 4	47.296 3	.06648 3	6501 2	12.46134 1	.33E-3 2	7.335942	33	2	.69
37972.0	39.79 6	177.053 5	47.298 4	.06678 4	1119 2	12.46208 1	.34E-3 2	7.333329	32	2	.82
37973.0	43.45 3	173.768 3	47.300 3	.06702 2	5743 1	12.462788 7	.31E-3 1	7.331123	38	2	.58
37974.0	47.04 3	170.479 3	47.302 3	.06713 2	03760 8	12.463480 6	.34E-3 9	7.330042	35	2	.49
37975.0	50.75 3	167.186 3	47.304 3	.06758 3	5011 1	12.46413 1	.31E-3 2	7.326275	35	2	.69
37976.0	54.56 6	163.902 5	47.310 5	.06789 5	9650 2	12.46438 9	.55E-3 9	7.323773	18	2	.74
37977.0	58.10 4	160.609 4	47.308 4	.06798 3	4302 1	12.46512 1	.19E-3 2	7.322708	28	2	.76
37978.0	61.80 5	157.326 5	47.307 4	.06820 4	8953 2	12.46565 1	.26E-3 2	7.320744	26	2	.75
37979.0	65.27 3	154.024 4	47.297 3	.06833 3	3617 1	12.466146 8	.22E-3 1	7.319568	31	2	.57
37980.0	68.81 3	150.729 4	47.295 3	.06840 3	8284 1	12.466668 1	.30E-3 2	7.318807	27	2	.64
37981.0	72.50 7	147.445 7	47.302 5	.06849 4	2951 2	12.46718 4	.21E-3 5	7.317924	13	2	.64
37982.0	75.95 3	144.146 4	47.296 2	.06853 2	7630 1	12.467669 9	.25E-3 2	7.317374	11	2	.27
37983.0	79.50 5	140.842 4	47.294 2	.06842 3	2311 2	12.468188 9	.30E-3 2	7.318067	13	2	.43
37984.0	82.9 1	137.570 8	47.275 5	.06806 8	7002 3	12.46877 2	.34E-3 5	7.320654	18	2	1.37
37985.0	86.4 1	134.280 8	47.277 5	.06804 7	1697 3	12.46955 2	.49E-3 5	7.320512	21	2	1.31
37986.0	89.8 1	130.956 9	47.292 5	.06783 6	6402 4	12.46999 2	.28E-3 4	7.321940	17	2	.91
37987.0	93.3 1	127.659 9	47.291 4	.06772 5	1105 4	12.47045 3	.18E-3 5	7.322644	14	2	.80
37988.0	96.68 6	124.361 8	47.286 5	.06740 4	5819 2	12.47098 1	.28E-3 3	7.324986	13	2	.73
37989.0	100.25 4	121.061 6	47.292 4	.06697 4	0532 1	12.47145 2	.29E-3 3	7.328117	29	2	.85
37990.0	103.78 3	117.760 5	47.295 3	.06672 4	5250 1	12.472057 9	.32E-3 2	7.329915	36	2	.83
37991.0	107.27 4	114.466 6	47.296 4	.06618 5	9976 1	12.47261 1	.28E-3 2	7.333884	29	2	.95
37992.0	110.78 3	111.173 4	47.294 3	.06558 4	4705 1	12.473080 9	.21E-3 2	7.338401	32	2	.73
37993.0	114.29 4	107.876 4	47.294 3	.06515 4	9439 1	12.47337 1	.12E-3 2	7.341695	39	2	.88
37994.0	117.81 4	104.582 4	47.289 3	.06469 5	4174 1	12.47351 1	.5E-4 2	7.345272	35	2	.87
37995.0	121.38 4	101.289 4	47.288 3	.06399 5	8908 1	12.47355 8	.3E-4 2	7.350699	35	2	.81
37996.0	124.84 4	97.997 4	47.285 3	.06354 5	3645 1	12.47341 1	.3E-4 2	7.354325	32	2	.77
37997.0	128.40 5	94.708 6	47.283 3	.06314 6	8378 1	12.47339 1	.44E-4 3	7.357485	18	2	.71
37998.0	132.04 4	91.403 6	47.274 3	.06225 5	3107 1	12.47326 1	.1E-3 2	7.364492	21	2	.66

III. SAO mean elements - Satellite 1960 Iota 1

1-31 December 1962

T (MJD)	ω	Ω	i	c	M	n <sup>1/2</sup>	q	N	D	σ
37999.0	135.64 6	88.106 7	47.269 3	.06190 6	.7836 2	12.47309 1	-7E-4 2	7.367297	27	2 .81
38000.0	139.14 3	84.824 4	47.269 1	.06129 3	.25658 7	12.472421 5	-11E-3 1	7.372370	23	2 .37
38001.0	142.76 2	81.531 4	47.268 2	.06072 2	.72908 7	12.472129 6	-14E-3 9	7.376957	31	2 .38
38002.0	146.42 3	78.230 4	47.268 2	.06011 3	.20114 8	12.471853 6	-13E-3 1	7.381913	32	2 .38
38003.0	150.12 4	74.946 5	47.265 2	.05952 4	.6729 1	12.47161 1	-9E-4 3	7.386577	22	2 .45
38004.0	153.79 4	71.659 6	47.260 3	.05895 4	.1445 1	12.471351 7	-16E-3 2	7.391148	28	2 .50
38005.0	157.43 3	68.377 4	47.258 2	.05844 2	.61587 7	12.471037 5	-129E-3 9	7.395299	29	2 .31
38006.0	161.25 3	65.084 3	47.259 2	.05780 2	.08652 8	12.470706 5	-21E-3 1	7.400475	26	2 .31
38007.0	164.97 4	61.795 5	47.259 3	.05727 3	.5571 1	12.470366 6	-16E-3 1	7.404777	28	2 .49
38008.0	168.72 5	58.511 5	47.258 4	.05672 4	.0273 1	12.470059 8	-17E-3 1	7.409223	20	2 .51
38009.0	172.43 5	55.225 5	47.252 4	.05624 4	.4973 2	12.469706 8	-15E-3 2	7.413139	19	2 .47
38010.0	176.36 7	51.932 6	47.263 5	.05557 5	.9664 2	12.469401 8	-15E-3 1	7.418512	24	2 .61
38011.0	180.25 5	48.648 6	47.270 4	.05502 4	.4354 2	12.469106 9	-20E-3 1	7.422928	24	2 .56
38012.0	183.92 6	45.376 7	47.256 5	.05461 5	.9046 2	12.468763 9	-15E-3 2	7.426317	22	2 .58
38013.0	187.62 8	42.093 7	47.249 5	.05416 5	.3735 2	12.468436 7	-17E-3 1	7.429991	19	2 .49
38014.0	191.60 7	38.807 8	47.262 5	.05355 4	.8413 2	12.468067 8	-21E-3 2	7.434926	19	2 .48
38015.0	195.48 6	35.529 7	47.264 5	.05299 3	.3090 2	12.467728 6	-19E-3 1	7.439400	15	2 .34
38016.0	199.24 6	32.261 5	47.257 5	.05262 4	.7768 2	12.467421 7	-15E-3 1	7.442460	19	2 .42
38017.0	203.18 5	28.981 5	47.264 4	.05205 3	.2438 1	12.467136 7	-14E-3 1	7.447061	23	2 .47
38018.0	207.03 4	25.716 4	47.258 3	.05165 3	.7108 1	12.466891 5	-127E-3 9	7.450305	27	2 .41
38019.0	210.90 4	22.436 4	47.259 3	.05121 3	.1775 1	12.466627 6	-13E-3 1	7.453825	31	2 .48
38020.0	214.76 6	19.156 4	47.265 4	.05074 4	.6449 2	12.466351 7	-15E-3 1	7.457695	24	2 .52
38021.0	218.59 5	15.81 3	47.266 3	.05025 3	.1103 1	12.466062 5	-13E-3 9	7.461664	26	2 .46
38022.0	222.44 4	12.615 2	47.262 3	.04976 3	.5763 1	12.465789 6	-14E-3 1	7.465625	34	2 .46
38023.0	226.26 5	9.342 2	47.260 3	.04931 3	.0421 1	12.465521 5	-12E-3 1	7.469245	28	2 .42
38024.0	230.12 4	6.068 2	47.261 3	.04883 3	.5076 1	12.46528 1	-12E-3 2	7.473078	28	2 .39
38025.0	234.02 3	2.794 2	47.261 2	.04835 2	.9728 1	12.465022 5	-116E-3 8	7.476999	40	2 .38
38026.0	237.89 6	359.520 3	47.258 3	.04786 4	.4379 2	12.46479 2	-13E-3 2	7.480895	38	2 .44
38027.0	241.84 6	356.247 3	47.254 3	.04727 4	.9025 2	12.46453 1	-14E-3 2	7.485664	25	2 .42
38028.0	245.74 4	352.977 2	47.257 2	.04679 3	.3670 1	12.464316 6	-10E-3 1	7.489513	22	2 .30
38029.0	249.63 4	349.709 3	47.259 3	.04626 3	.8313 1	12.46414 1	-4E-4 2	7.493758	28	2 .31

Table 6

## RELATIVE POSITIONS OF THE SUN AND THE PERIGEE OF SATELLITE 1960 IOTA 1

MJD	Z	$\varphi$	$\psi$	D.R.A.	$\dot{P}$
PERIGEE IN SUNLIGHT					
37938	1009.	-47.3	45.8	13.3	-0.360E-05
37939	1008.	-47.1	45.6	14.6	-0.349E-05
37940	1006.	-46.6	45.1	15.9	-0.323E-05
37941	1005.	-45.9	44.4	17.0	-0.275E-05
37942	1003.	-45.0	43.4	17.9	-0.245E-05
37943	1002.	-43.7	42.3	18.8	-0.258E-05
37944	1001.	-42.3	40.9	19.4	-0.310E-05
37945	999.	-40.7	39.3	19.8	-0.271E-05
37946	998.	-39.0	37.6	19.9	-0.323E-05
37947	996.	-37.1	35.6	19.9	-0.297E-05
37948	995.	-35.0	33.5	19.6	-0.297E-05
37949	993.	-32.9	31.2	19.1	-0.323E-05
37950	993.	-30.6	28.8	18.4	-0.349E-05
37951	992.	-28.1	26.3	17.8	-0.400E-05
37952	990.	-25.6	23.7	16.9	-0.348E-05
37953	990.	-23.1	20.9	15.7	-0.374E-05
37954	988.	-20.5	18.1	14.5	-0.400E-05
37955	987.	-17.9	15.4	13.1	-0.413E-05
37956	986.	-15.2	12.7	11.8	-0.297E-05
37957	985.	-12.3	10.5	10.4	-0.400E-05
37958	983.	-9.6	8.8	8.9	-0.374E-05
37959	982.	-6.7	8.3	7.3	-0.413E-05
37960	980.	-3.9	9.3	5.8	-0.426E-05

Table 6 (cont.)

## RELATIVE POSITIONS OF THE SUN AND THE PERIGEE OF SATELLITE 1960 IOTA 1

MJD	Z	$\Psi$	$\dot{\Psi}$	D.R.A.	$\dot{P}$
37961.	979.	-1.1	11.1	4.1	-0.413E-05
37962.	977.	1.6	13.7	2.4	-0.464E-05
37963.	976.	4.4	16.6	0.8	-0.529E-05
37964.	973.	7.3	19.8	359.2	-0.503E-05
37965.	972.	10.0	23.0	357.6	-0.503E-05
37966.	970.	12.7	26.3	356.0	-0.477E-05
37967.	969.	15.5	29.6	354.5	-0.387E-05
37968.	968.	18.1	32.7	353.0	-0.528E-05
37969.	965.	20.7	35.9	351.6	-0.399E-05
37970.	963.	23.2	38.9	350.2	-0.451E-05
37971.	962.	25.7	41.9	349.0	-0.425E-05
37972.	960.	28.1	44.8	347.8	-0.438E-05
37973.	958.	30.4	47.6	346.8	-0.399E-05
37974.	958.	32.5	50.2	345.9	-0.445E-05
37975.	955.	34.7	52.7	345.2	-0.399E-05
37976.	953.	36.8	55.0	344.9	-0.708E-05
37977.	953.	38.6	57.2	344.4	-0.245E-05
37978.	951.	40.4	59.1	344.3	-0.335E-05
37979.	951.	41.9	60.9	344.2	-0.283E-05
37980.	951.	43.2	62.4	344.3	-0.386E-05
37981.	950.	44.5	63.8	344.8	-0.270E-05
37982.	950.	45.5	64.9	345.2	-0.322E-05
37983.	951.	46.3	65.8	345.8	-0.386E-05

Table 6 (cont.)

## RELATIVE POSITIONS OF THE SUN AND THE PERIGEE OF SATELLITE 1960 IOTA 1

MJD	Z	$\Phi$	$\Psi$	D.R.A.	$\dot{P}$
37984.	954.	46.8	66.5	346.4	-0.437E-05
37985.	954.	47.2	67.0	347.2	-0.630E-05
37986.	955.	47.3	67.3	347.8	-0.360E-05
37987.	956.	47.2	67.3	348.7	-0.231E-05
37988.	958.	46.9	67.1	349.3	-0.360E-05
37989.	961.	46.3	66.7	350.0	-0.373E-05
37990.	962.	45.5	66.1	350.6	-0.411E-05
37991.	966.	44.6	65.3	351.0	-0.360E-05
37992.	970.	43.4	64.3	351.3	-0.270E-05
37993.	973.	42.1	63.2	351.4	-0.154E-05
37994.	976.	40.5	61.9	351.2	-0.643E-06
37995.	981.	38.9	60.4	351.0	0.386E-06
37996.	984.	37.1	59.0	350.4	-0.386E-06
37997.	986.	35.2	57.4	349.7	0.514E-06
37998.	992.	33.1	55.6	348.9	0.129E-05
37999.	995.	30.9	53.9	348.0	0.900E-06
38000.	999.	28.7	52.2	346.8	0.141E-05
38001.	1003.	26.4	50.4	345.5	0.190E-05
38002.	1007.	24.0	48.6	344.2	0.167E-05
38003.	1011.	21.5	46.9	342.7	0.116E-05
38004.	1015.	18.9	45.2	341.2	0.206E-05
38005.	1019.	16.4	43.8	339.5	0.166E-05
38006.	1023.	13.7	42.2	337.9	0.270E-05

Table 6 (cont.)

## RELATIVE POSITIONS OF THE SUN AND THE PERIGEE OF SATELLITE 1960 IOTA 1

MJD	Z	$\Phi$	$\Psi$	D.R.A.	$\dot{P}$
38007.	1027.	11.0	41.0	336.2	0.206E-05
38008.	1031.	8.3	39.9	334.4	0.219E-05
38009.	1035.	5.6	39.1	332.6	0.193E-05
38010.	1040.	2.7	38.3	330.9	0.193E-05
38011.	1045.	-0.2	37.7	329.2	0.257E-05
38012.	1048.	-2.9	37.6	327.3	0.193E-05
38013.	1052.	-5.6	37.7	325.4	0.219E-05
38014.	1057.	-8.5	37.7	323.8	0.270E-05
38015.	1062.	-11.3	38.0	322.1	0.244E-05
38016.	1065.	-14.0	38.5	320.4	0.193E-05
38017.	1070.	-16.8	39.0	318.9	0.180E-05
38018.	1074.	-19.5	39.7	317.4	0.163E-05
38019.	1078.	-22.2	40.4	316.0	0.167E-05
38020.	1083.	-24.8	41.1	314.7	0.193E-05
38021.	1088.	-27.3	41.9	313.6	0.174E-05
38022.	1093.	-29.7	42.6	312.6	0.180E-05
38023.	1097.	-32.0	43.2	311.7	0.154E-05
38024.	1102.	-34.3	43.8	311.1	0.154E-05
38025.	1106.	-36.5	44.2	310.7	0.149E-05
38026.	1111.	-38.5	44.5	310.5	0.167E-05
38027.	1116.	-40.3	44.7	310.6	0.180E-05
38028.	1121.	-42.0	44.7	310.9	0.129E-05
38029.	1126.	-43.5	44.6	311.4	0.515E-06

Satellite 1960 E1 1 (Explorer VIII)

Joan Weingarten

I. SAO smoothed elements

The following elements are based on 97 observations and are valid for the period October 1 through November 1, 1962.

$$T_o = 37954.0 \text{ MJD}$$

$$\omega = (252^\circ 474 \pm 7) + (2^\circ 8155 \pm 8)t + .0001592t^2 + .3459 \cos \omega$$

$$\Omega = (128^\circ 170 \pm 2) - (3^\circ 3871 \pm 2)t + .812 \times 10^{-6}t^2 + .0142 \cos \omega$$

$$i = (49^\circ 948 \pm 2) + .6824 \times 10^{-4}t - .0042 \sin \omega$$

$$e = (.119344 \pm 7) - .1047 \times 10^{-4}t + .0007287 \sin \omega$$

$$M = (.40284 \pm 2) + (12.806620 \pm 2)t + (.1437 \pm 3) \times 10^{-4}t^2 + (.101 \pm 4) \times 10^{-6}t^3 \\ - .0008870 \cos \omega$$

Standard error of one observation:  $\sigma = \pm 1^\circ 33.$

The following elements are based on 110 observations and are valid for the period November 1 through December 1, 1962.

$$T_o = 37984.0 \text{ MJD}$$

$$\omega = (336^\circ 844 \pm 7) + (2^\circ 8144 \pm 6)t + .0001592t^2 + .3459 \cos \omega$$

$$\Omega = (26^\circ 556 \pm 1) - (3^\circ 3874 \pm 2)t + .812 \times 10^{-6}t^2 + .0142 \cos \omega$$

$$i = (49^\circ 954 \pm 1) + .6824 \times 10^{-4}t - .0042 \sin \omega$$

$$e = (.11928 \pm 1) - .1047 \times 10^{-4}t + .0007287 \sin \omega$$

$$M = (.61545 \pm 2) + (12.807494 \pm 2)t + (.1322 \pm 3) \times 10^{-4}t^2 + (.54 \pm 4) \times 10^{-7}t^3 \\ - .0008870 \cos \omega$$

Standard error of one observation:  $\sigma = \pm 1^\circ 20.$

The following elements are based on 95 observations and are valid for the period December 1, 1962 through January 1, 1963.

$$T_o = 38014.0 \text{ MJD}$$

$$\omega = (61^\circ 239 \pm 6) + (2^\circ 8158 \pm 4)t + .0001592t^2 + .3459 \cos \omega$$

$$\Omega = (284^\circ 922 \pm 2) - (3^\circ 3880 \pm 1)t + .812 \times 10^{-6} t^2 + .0142 \cos \omega$$

$$i = (49^\circ 950 \pm 1) + .6824 \times 10^{-4}t - .0042 \sin \omega$$

$$e = (.11918 \pm 2) - .1047 \times 10^{-4}t + .0007287 \sin \omega$$

$$M = (.85498 \pm 2) + (12.808567 \pm 1)t + (.1854 \pm 3) \times 10^{-4}t^2 - (.181 \pm 4) \times 10^{-6}t^3 \\ - .0008870 \cos \omega$$

Standard error of one observation:  $\sigma = \pm 1.60$ .

T (MJD)	w	Ω	i	e	N	n	n' n'/2	q	N	D	σ
37940.0	212.7 2	175.55 6	49.95 2	.119 2	.1139 4	12.80622 1	.19E-4 6	6.796091	14	6	1.19
37944.0	224.07 4	162.01 1	49.960 8	.1184 4	.33854 7	12.806313 3	.6E-5 2	6.802951	20	6	.49
37948.0	235.49 4	148.47 1	49.96 1	.1192 4	.56395 8	12.806404 8	.13E-4 4	6.797064	16	6	.48
37952.0	246.67 2	134.940 3	49.960 4	.11856 2	.79006 5	12.806511 3	.11E-4 1	6.801827	12	6	.42
37956.0	258.04 1	121.394 2	49.952 2	.118583 8	.01631 3	12.806628 2	.15E-4 1	6.801611	21	6	.42
37960.0	269.34 2	107.850 2	49.951 2	.118565 9	.24317 4	12.806743 2	.18E-4 1	6.801703	20	6	.45
37964.0	280.69 1	94.300 2	49.950 3	.11854 1	.47046 4	12.806887 2	.202E-4 9	6.801855	25	6	.45
37968.0	291.98 2	80.763 4	49.960 3	.1187 2	.69842 9	12.807009 2	.12E-4 9	6.800478	29	6	.36
37972.0	303.30 2	67.194 8	49.945 5	.1182 2	.9270 1	12.807100 2	.12E-4 1	6.804503	30	6	.39
37976.0	314.62 2	53.66 1	49.951 3	.11869 6	.15562 7	12.807221 4	.17E-4 2	6.800608	19	6	.51
37980.0	325.88 3	40.11 2	49.953 5	.11882 8	.3850 1	12.807337 5	.12E-4 5	6.799537	12	6	.86
37984.0	337.19 2	26.565 8	49.954 5	.11894 3	.61455 5	12.807418 3	.22E-4 2	6.798576	15	6	.61
37988.0	348.46 2	13.036 7	49.947 5	.11912 3	.84470 4	12.807533 3	.11E-4 2	6.797111	21	6	.50
37992.0	359.65 6	359.458 8	49.965 7	.1190 2	.0756 3	12.807660 2	.18E-4 1	6.797954	25	6	.36
37996.0	11.02 1	345.925 2	49.949 3	.11949 4	.30632 4	12.807766 3	.12E-4 1	6.794181	26	6	.46
38000.0	22.166 8	332.368 2	49.950 2	.11949 2	.53834 2	12.807925 3	.20E-4 1	6.794167	32	6	.49
38004.0	33.434 6	318.817 2	49.952 2	.11964 2	.77050 2	12.808107 1	.26E-4 1	6.792917	30	6	.52
38008.0	44.69 2	305.26 1	49.951 8	.11972 6	.00342 5	12.808264 8	.12E-4 4	6.792280	14	6	1.00
38012.0	55.5 1	291.708 9	49.95 1	.1195 2	.2384 5	12.808431 3	.18E-4 2	6.794274	10	6	.42
38016.0	66.9 1	278.151 7	49.946 6	.1197 2	.4723 4	12.80859 4	.17E-4 3	6.792644	20	6	.47
38020.0	78.1 1	264.600 7	49.945 6	.1197 2	.7072 4	12.808761 8	.22E-4 3	6.792579	20	6	.42
38024.0	100.55 1	237.484 3	49.945 2	.11998 4	.17842 2	12.80896 2	.3E-5 6	6.790007	14	6	.49

Table 7

RELATIVE POSITIONS OF THE SUN AND THE PERIGEE OF SATELLITE 1960 XI 1

MJD	Z	$\varphi$	$\psi$	D.R.A.	$\dot{P}$
PERIGEE IN EARTH SHADOW					
37940.	421.	-24.4	150.4	189.4	-0.232E-06
37944.	431.	-32.2	142.6	181.7	-0.732E-07
37948.	427.	-39.1	134.0	175.7	-0.159E-06
37952.	434.	-44.7	126.5	171.5	-0.134E-06
37956.	435.	-48.5	121.1	169.9	-0.183E-06
37960.	436.	-49.9	118.2	169.8	-0.219E-06
37964.	436.	-48.8	118.0	169.8	-0.246E-06
37968.	433.	-45.2	119.9	168.1	-0.154E-06
37972.	435.	-39.8	123.1	164.1	-0.146E-06
37976.	429.	-33.0	126.3	157.9	-0.207E-06
37980.	425.	-25.4	128.0	149.9	-0.146E-06
37984.	422.	-17.3	127.3	140.7	-0.268E-06
37988.	419.	-8.8	123.7	130.6	-0.134E-06
37992.	420.	-0.3	118.0	120.1	-0.219E-06
37996.	416.	8.4	111.3	109.7	-0.146E-06
PERIGEE IN SUNLIGHT					
38000.	418.	16.8	104.6	99.4	-0.244E-06
38004.	418.	24.9	99.1	89.8	-0.317E-06
38008.	420.	32.6	95.3	81.4	-0.146E-06
38012.	424.	39.1	93.0	74.1	-0.219E-06
38016.	425.	44.8	92.9	69.4	-0.207E-06
38020.	426.	48.5	93.4	66.8	-0.268E-06
38028.	424.	48.8	92.4	65.1	-0.366E-07

Satellite 1961 Delta 1 (Explorer IX)

Joan Weingarten

## I. SAO smoothed elements

The following elements are based on 134 observations and are valid for the period September 30 through October 15, 1962.

$$T_o = 37945.0 \text{ MJD}$$

$$\omega = (83^\circ 959 \pm 5) + (4^\circ 810 \pm 1)t + .0001445t^2 + .2752 \cos \omega$$

$$\Omega = (154^\circ 382 \pm 2) - (3^\circ 6680 \pm 4)t - .0001634t^2 + .0059 \cos \omega$$

$$i = (38^\circ 8428 \pm 8) + .0001714t - .0040 \sin \omega$$

$$e = (.11147 \pm 2) + (.78 \pm 4) \times 10^{-4} t + .643 \times 10^{-6} t^2 + .0005260 \sin \omega$$

$$M = (.11197 \pm 2) + (12.224849 \pm 4)t + (.00015526 \pm 9)t^2 + (.39 \pm 2) \times 10^{-6} t^3 \\ - .0007693 \cos \omega$$

Standard error of one observation:  $\sigma = \pm 11.15$ .

The following elements are based on 205 observations and are valid for the period October 15 through October 31, 1962.

$$T_o = 37960.0 \text{ MJD}$$

$$\omega = (156^\circ 179 \pm 9) + (4^\circ 822 \pm 2)t + .0001445t^2 + .2752 \cos \omega$$

$$\Omega = (99^\circ 318 \pm 2) - (3^\circ 6735 \pm 4)t - .0001634t^2 + .0059 \cos \omega$$

$$i = (38^\circ 850 \pm 1) + .0001714t - .0040 \sin \omega$$

$$e = (.11241 \pm 2) + (.36 \pm 5) \times 10^{-4} t + .643 \times 10^{-6} t^2 + .0005260 \sin \omega$$

$$M = (.51882 \pm 3) + (12.229194 \pm 7)t + (.0001434 \pm 1)t^2 + (.173 \pm 3) \times 10^{-5} t^3 \\ - .0007693 \cos \omega$$

Standard error of one observation:  $\sigma = \pm 11.93$ .

The following elements are based on 194 observations and are valid for the period October 31 through November 15, 1962.

$$\begin{aligned}
 T_o &= 37976.0 \text{ MJD} \\
 \omega &= (233^\circ 420 \pm 6) + (4^\circ 832 \pm 1)t + .0001445t^2 + .2752 \cos \omega \\
 \Omega &= (40^\circ 524 \pm 2) - (3^\circ 6763 \pm 4)t - .0001634t^2 + .0059 \cos \omega \\
 i &= (38^\circ 8552 \pm 6) + .0001714t - .0040 \sin \omega \\
 e &= (.11320 \pm 1) + (.69 \pm 3) \times 10^{-4} t + .643 \times 10^{-6} t^2 + .0005260 \sin \omega \\
 M &= (.22590 \pm 2) + (12.234195 \pm 4)t + (.00015709 \pm 8)t^2 - (.40 \pm 19) \times 10^{-7} t^3 \\
 &\quad - .0007693 \cos \omega
 \end{aligned}$$

Standard error of one observation:  $\sigma = \pm 1.10$ .

The following elements are based on 135 observations and are valid for the period November 15 through November 30, 1962.

$$\begin{aligned}
 T_o &= 37991.0 \text{ MJD} \\
 \omega &= (305^\circ 82 \pm 1) + (4^\circ 829 \pm 2)t + .0001445t^2 + .2752 \cos \omega \\
 \Omega &= (345^\circ 333 \pm 3) - (3^\circ 6824 \pm 6)t - .0001634t^2 + .0059 \cos \omega \\
 i &= (38^\circ 857 \pm 2) + .0001714t - .0040 \sin \omega \\
 e &= (.11416 \pm 3) + (.71 \pm 6) \times 10^{-4} t + .643 \times 10^{-6} t^2 + .0005260 \sin \omega \\
 M &= (.77593 \pm 3) + (12.239233 \pm 6)t + (.0001691 \pm 2)t^2 - (.41 \pm 3) \times 10^{-6} t^3 \\
 &\quad - .0007693 \cos \omega
 \end{aligned}$$

Standard error of one observation:  $\sigma = \pm 1.95$ .

The following elements are based on 140 observations and are valid for the period November 30 through December 15, 1962.

$$\begin{aligned}
 T_o &= 38006.0 \text{ MJD} \\
 \omega &= (18^\circ 308 \pm 4) + (4^\circ 8315 \pm 8)t + .0001445t^2 + .2752 \cos \omega \\
 \Omega &= (290^\circ 060 \pm 2) - (3^\circ 6871 \pm 3)t - .0001634t^2 + .0059 \cos \omega \\
 i &= (38^\circ 8537 \pm 8) + .0001714t - .0040 \sin \omega \\
 e &= (.11533 \pm 2) + (.79 \pm 3) \times 10^{-4} t + .643 \times 10^{-6} t^2 + .0005260 \sin \omega \\
 M &= (.40194 \pm 1) + (12.244362 \pm 2)t + (.00018534 \pm 6)t^2 + (.65 \pm 2) \times 10^{-6} t^3 \\
 &\quad - .0007693 \cos \omega
 \end{aligned}$$

Standard error of one observation:  $\sigma = \pm 1.10$ .

The following elements are based on 150 observations and are valid for the period December 15 through December 31, 1962.

$$T_o = 38021.0 \text{ MJD}$$

$$\omega = (90^\circ 750 \pm 3) + (4^\circ 8228 \pm 7)t + .0001445t^2 + .2752 \cos \omega$$

$$\Omega = (234^\circ 691 \pm 2) - (3^\circ 6941 \pm 4)t - .0001534t^2 + .0059 \cos \omega$$

$$i = (38^\circ 8558 \pm 7) + .0001714t - .0040 \sin \omega$$

$$e = (.11661 \pm 1) + (.85 \pm 3) \times 10^{-4}t + .643 \times 10^{-6}t^2 + .0005260 \sin \omega$$

$$M = (.110102 \pm 7) + (12.249977 \pm 2)t + (.00015040 \pm 8)t^2 - (.395 \pm 2) \times 10^{-5}t^3 \\ - .0007693 \cos \omega$$

Standard error of one observation:  $\sigma = \pm 1^\circ 20.$

## II. SAO mean elements - Satellite 1961 Delta 1

1-31 October 1962

T (MJD)	$\omega$	$\Omega$	i	e	M	n	$n^{1/2}$	q	N	D	$\sigma$	
37938.0	50.471	180.056	3	38.837	1	.11140	3	.54498	3	12.222746	4	
37939.0	55.261	176.397	5	38.835	2	.11149	3	.76791	3	12.223054	6	
37940.0	60.039	9	172.722	4	38.837	1	.11159	2	.99116	3	12.223394	3
37941.0	64.812	169.053	6	38.837	2	.11163	4	.21478	4	12.223696	6	
37942.0	69.592	165.391	7	38.835	3	.11171	5	.43865	6	12.223997	7	
37943.0	74.421	161.725	4	38.837	2	.11187	3	.66266	3	12.224280	8	
37944.0	79.211	158.059	5	38.840	2	.11201	5	.88709	4	12.224579	6	
37945.0	83.990	9	154.382	3	38.840	2	.11187	3	.11187	3	12.224884	4
37946.0	88.780	7	150.714	3	38.840	1	.11210	2	.33691	2	12.225215	4
37947.0	93.571	147.048	3	38.841	2	.11216	3	.56232	3	12.225544	7	
37948.0	98.364	143.441	3	38.851	8	.11226	2	.7879	2	12.225853	3	
37949.0	103.134	139.732	2	38.847	8	.11226	1	.0140	1	12.226142	2	
37950.0	107.913	136.051	1	38.842	5	.11225	1	.2404	1	12.226502	2	
37951.0	112.702	132.369	7	38.845	3	.112260	6	.46708	6	12.226800	9	
37952.0	117.544	128.692	9	38.846	5	.11226	2	.6939	1	12.227112	2	
37953.0	122.365	125.013	9	38.849	6	.11228	2	.9210	2	12.227413	3	
37954.0	127.095	121.351	1	38.848	8	.11226	1	.1488	2	12.227702	2	
37955.0	131.863	117.681	3	38.843	6	.11225	1	.3767	1	12.227992	3	
37956.0	136.643	114.001	1	38.844	5	.11224	1	.6050	1	12.228253	3	
37957.0	141.448	2	110.327	4	38.846	2	.11258	4	.83316	7	12.228476	8
37958.0	146.292	106.654	3	38.846	1	.11264	3	.06173	5	12.228696	6	
37959.0	151.102	102.985	3	38.848	1	.11264	3	.29056	5	12.228937	9	
37960.0	155.922	99.312	4	38.850	2	.11257	3	.51959	7	12.229205	8	
37961.0	160.712	95.638	3	38.850	2	.11255	3	.74899	5	12.229472	6	
37962.0	165.521	91.961	3	38.851	2	.11256	3	.97863	5	12.229745	5	
37963.0	170.352	88.287	3	38.852	2	.11258	3	.20853	5	12.230101	1	
37964.0	175.162	84.614	3	38.850	3	.11255	4	.43884	8	12.230438	7	
37965.0	180.012	80.939	2	38.852	2	.11259	3	.66939	5	12.230797	5	
37966.0	184.842	77.265	2	38.853	2	.11262	3	.90031	5	12.231124	4	
37967.0	189.662	73.592	3	38.853	2	.11256	4	.13163	7	12.231420	6	
37968.0	194.512	69.914	3	38.851	2	.11256	3	.36315	6	12.231701	6	

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## III. SAO mean elements - Satellite 1961 Delta 1

1-30 November 1962

$\Pi$ (MJD)	$\omega$	$\Omega$	$i$	$e$	$M$	$n$	$n'/2$	$q$	$N$	$D$	$\sigma$
37969.0	199.40 2	66.245 3	38.855 2.	.11268 3	.59480 6	12.232013 6	.16E-3 1	7.059291	.32	2	.42
37970.0	204.21 1	62.569 2	38.855 1	.11265 2	.82705 4	12.232306 5	.149E-3 9	7.059430	.35	2	.21
37971.0	209.03 1	58.897 3	38.856 1	.11265 2	.05953 4	12.232611 5	.156E-3 9	7.059487	.36	2	.25
37972.0	213.85 1	55.224 3	38.858 1	.11263 3	.29233 4	12.232899 4	.16E-3 1	7.059283	.29	2	.27
37973.0	218.70 2	51.548 4	38.858 1	.11263 3	.52537 5	12.233235 7	.14E-3 1	7.059142	.35	2	.04
37974.0	223.57 2	47.871 4	38.856 1	.11272 3	.75664 6	12.233527 6	.157E-3 9	7.058274	.28	2	.22
37975.0	228.43 2	44.201 5	38.857 1	.11278 3	.99228 5	12.233854 6	.16E-3 1	7.057782	.25	2	.20
37976.0	233.27 2	40.523 3	38.854 1	.11280 3	.22429 5	12.234171 6	.17E-3 1	7.057493	.20	2	.23
37977.0	238.14 3	36.836 7	38.865 3	.11308 7	.4605 1	12.23460 1	.26E-3 2	7.055045	.16	2	.65
37978.0	242.99 3	33.159 4	38.859 2	.11289 6	.69522 7	12.23480 1	.11E-3 3	7.056518	.17	2	.33
37979.0	247.81 2	29.489 4	38.859 2	.11295 3	.93020 5	12.23507 6	.197E-3 9	7.055935	.23	2	.41
37980.0	252.66 2	25.818 6	38.861 2	.11303 5	.16547 6	12.235404 9	.13E-3 1	7.055177	.26	2	.52
37981.0	257.51 3	22.14 1	38.860 3	.11303 8	.4010 1	12.23570 1	.15E-3 2	7.055053	.22	2	.48
37982.0	262.33 2	18.45 1	38.860 3	.11310 6	.63697 8	12.236006 9	.19E-3 2	7.054239	.18	2	.32
37983.0	267.21 2	14.777 6	38.861 3	.11316 5	.87306 6	12.23634 2	.18E-3 2	7.053758	.14	2	.41
37984.0	272.06 1	11.101 5	38.859 3	.11321 4	.10957 4	12.23672 3	.20E-3 3	7.053192	.12	2	.34
37985.0	276.89 2	7.41 1	38.861 3	.11324 8	.34659 8	12.237121 8	.18E-3 1	7.052822	.12	2	.35
37986.0	281.78 4	3.74 2	38.867 7	.1134 1	.5838 1	12.23747 2	.16E-3 2	7.051022	.17	2	.77
37987.0	286.63 3	.061 9	38.862 4	.11345 7	.82143 7	12.23779 1	.17E-3 2	7.050886	.17	2	.50
37988.0	291.69 3	356.31 1	38.895 6	.11419 9	.05895 9	12.23810 2	.15E-3 3	7.044934	.16	2	.79
37989.0	296.54 4	352.63 1	38.892 9	.1143 1	.2972 1	12.23843 1	.22E-3 4	7.043887	.15	2	1.05
37990.0	301.02 5	349.06 2	38.84 1	.1138 1	.5367 1	12.23877 1	.15E-3 3	7.047866	.19	2	.66
37991.0	306.3 3	345.31 1	38.875 8	.1137 1	.7741 8	12.239175 9	.23E-3 2	7.048018	.19	2	.37
37992.0	311.5 4	341.63 2	38.87 1	.1138 1	.012 1	12.23952 2	.18E-3 4	7.047786	.9	2	.37
37993.0	315.72 5	337.96 9	38.860 9	.1140 1	.2543 1	12.23992 3	.12E-3 5	7.046092	.9	2	.56
37994.0	320.93 3	334.289 6	38.858 5	.11400 7	.49447 8	12.240218 8	.20E-3 2	7.045567	.16	2	.39
37995.0	325.37 2	330.606 4	38.860 4	.11409 4	.73492 5	12.240547 9	.12E-3 2	7.044792	.22	2	.45
37996.0	330.21 1	326.923 3	38.861 3	.11422 3	.97561 3	12.240845 6	.16E-3 1	7.043631	.28	2	.45
37997.0	335.058 8	323.239 2	38.861 2	.11440 3	.21660 2	12.241163 4	.157E-3 7	7.042058	.28	2	.39
37998.0	339.901 9	319.554 2	38.860 3	.11455 3	.45792 2	12.241479 4	.15E-3 1	7.040781	.24	2	.35

## II. SAO mean elements - Satellite 1961 Delta 1

1-31 December 1962

T (MJD)	$\omega$	$\Omega$	1	e	M	n	$n'/2$	q	N	D	$\sigma$
37999.0	344.74 2	315.867 4	38.853 4	.11463 4	.69958 4	12.241840 9	.18E-3 2	7.039958	19	2	.46
38000.0	349.60 1	312.172 5	38.849 4	.11473 4	.94157 3	12.242188 9	.17E-3 1	7.039063	18	2	.43
38001.0	354.43 1	308.501 5	38.857 3	.11487 5	.18393 4	12.242525 7	.16E-3 1	7.037824	20	2	.42
38002.0	359.27 1	304.825 4	38.863 2	.11504 3	.42658 2	12.242862 4	.160E-3 8	7.036330	17	2	.32
38003.0	4.092 9	301.138 5	38.862 3	.11513 3	.66966 2	12.243255 6	.21E-3 1	7.035447	16	2	.31
38004.0	8.918 8	297.452 4	38.857 2	.11524 3	.91315 2	12.243658 4	.163E-3 8	7.034421	18	2	.31
38005.0	13.749 9	293.764 5	38.857 2	.11530 4	.15699 2	12.244016 5	.182E-3 7	7.033843	20	2	.37
38006.0	18.57 2	290.063 8	38.854 3	.11531 6	.40125 4	12.24439 1	.18E-3 2	7.033577	22	2	.61
38007.0	23.41 1	286.367 7	38.852 2	.11550 5	.64579 4	12.244748 5	.19E-3 1	7.031960	20	2	.50
38008.0	28.22 1	282.686 8	38.853 2	.11571 5	.89075 3	12.245125 7	.17E-3 2	7.030157	20	2	.48
38009.0	33.05 1	279.010 5	38.851 2	.11597 5	.13600 2	12.245498 7	.18E-3 1	7.027791	20	2	.34
38010.0	37.882 6	275.318 3	38.851 2	.11609 4	.38167 2	12.245885 8	.20E-3 1	7.026770	19	2	.23
38011.0	42.67 1	271.618 6	38.853 2	.11604 5	.62790 3	12.246313 5	.23E-3 2	7.027040	18	2	.42
38012.0	47.491 9	267.924 5	38.850 2	.11622 4	.87443 2	12.246714 9	.18E-3 2	7.025454	18	2	.41
38013.0	52.315 8	264.239 5	38.847 2	.11639 4	.12129 2	12.247087 4	.197E-3 8	7.023955	17	2	.38
38014.0	57.128 8	260.548 5	38.849 2	.11649 4	.36859 2	12.247439 8	.15E-3 1	7.023045	20	2	.47
38015.0	61.944 8	256.854 5	38.850 2	.11659 5	.61620 2	12.247769 7	.17E-3 1	7.022102	20	2	.44
38016.0	66.751 7	253.150 4	38.848 1	.11666 4	.86421 2	12.248160 5	.22E-3 1	7.021379	16	2	.34
38017.0	71.538 9	249.459 5	38.849 2	.11678 5	.11266 2	12.248583 8	.19E-3 1	7.020307	24	2	.58
38018.0	76.335 8	245.773 5	38.851 2	.11693 4	.16147 2	12.248967 8	.21E-3 2	7.018932	28	2	.54
38019.0	81.154 7	242.076 4	38.855 1	.11703 4	.01063 2	12.249323 6	.17E-3 1	7.018015	25	2	.48
38020.0	85.956 6	238.380 3	38.851 1	.11704 3	.86021 1	12.249698 4	.160E-3 8	7.017837	22	2	.38
38021.0	90.751 9	234.693 4	38.851 2	.11717 4	.11010 2	12.249992 6	.139E-3 9	7.016659	17	2	.45
38022.0	95.54 1	231.001 4	38.851 2	.11727 4	.36031 2	12.250288 6	.16E-3 2	7.015783	21	2	.47
38023.0	100.348 7	227.305 3	38.852 2	.11734 3	.61076 2	12.250544 3	.12E-3 1	7.015127	22	2	.36
38024.0	105.139 8	223.608 5	38.856 2	.11745 5	.86148 3	12.250783 8	.13E-3 2	7.014160	21	2	.43
38025.0	109.943 7	219.903 3	38.854 2	.11741 4	.11247 2	12.251023 6	.123E-3 9	7.014356	23	2	.46
38026.0	114.739 9	216.208 4	38.854 2	.11743 4	.36369 2	12.25120 1	.4E-4 2	7.014155	18	2	.52
38027.0	119.562 8	212.517 4	38.858 2	.11748 4	.61493 2	12.251319 7	.9E-4 1	7.013667	18	2	.37
38028.0	124.389 7	208.822 4	38.856 2	.11759 4	.86631 2	12.251450 5	.4E-4 1	7.012759	15	2	.40
38029.0	129.20 1	205.115 6	38.854 3	.11754 5	.11787 4	12.251528 2	.6E-4 3	7.013105	10	2	.46

Table 8

## RELATIVE POSITIONS OF THE SUN AND THE PERIGEE OF SATELLITE 1961 DELTA 1

MJD	Z	$\phi$	$\psi$	D.R.A.	$\dot{P}$
PERIGEE IN SUNLIGHT					
37938.	700.	28.9	47.4	36.7	-0.321E-05
37939.	699.	31.0	49.2	37.1	-0.134E-05
37940.	699.	32.9	51.1	37.7	-0.244E-05
37941.	699.	34.6	52.9	38.5	-0.174E-05
37942.	699.	36.0	54.8	39.5	-0.201E-05
37943.	698.	37.2	56.6	40.8	-0.147E-05
37944.	697.	38.0	58.3	42.1	-0.201E-05
37945.	697.	38.6	59.8	43.6	-0.221E-05
37946.	697.	38.8	61.2	45.1	-0.246E-05
37947.	696.	38.8	62.5	46.7	-0.174E-05
37948.	692.	38.4	63.5	48.2	-0.214E-05
37949.	692.	37.7	64.3	49.6	-0.161E-05
37950.	692.	36.6	64.9	50.9	-0.294E-05
37951.	691.	35.4	65.3	52.0	-0.161E-05
37952.	690.	33.8	65.4	52.9	-0.268E-05
37953.	688.	32.0	65.3	53.7	-0.201E-05
37954.	688.	30.0	65.0	54.1	-0.174E-05
37955.	688.	27.8	64.4	54.3	-0.214E-05
37956.	688.	25.5	63.6	54.4	-0.107E-05
37957.	686.	23.0	62.6	54.3	-0.174E-05
37958.	685.	20.4	61.4	54.0	-0.160E-05
37959.	684.	17.6	60.1	53.6	-0.147E-05
37960.	684.	14.8	58.6	53.1	-0.160E-05

Table 8 (cont.)

## RELATIVE POSITIONS OF THE SUN AND THE PERIGEE OF SATELLITE 1961 DELTA 1

MJD	Z	$\varphi$	$\psi$	D.R.A.	$\dot{P}$
37961.	684.	12.0	57.1	52.4	-0.201E-05
37962.	683.	9.0	55.4	51.6	-0.201E-05
37963.	683.	6.0	53.7	50.8	-0.214E-05
37964.	683.	3.0	52.0	50.0	-0.241E-05
37965.	682.	-0.0	50.3	49.1	-0.227E-05
37966.	682.	-3.0	48.7	48.2	-0.214E-05
37967.	682.	-6.0	47.2	47.4	-0.187E-05
37968.	682.	-9.0	45.8	46.6	-0.201E-05
37969.	682.	-12.0	44.6	45.9	-0.214E-05
37970.	682.	-14.9	43.6	45.2	-0.199E-05
37971.	683.	-17.7	42.8	44.6	-0.209E-05
37972.	684.	-20.5	42.2	44.1	-0.214E-05
37973.	684.	-23.1	41.9	43.9	-0.187E-05
37974.	684.	-25.6	41.9	43.8	-0.210E-05
37975.	684.	-28.0	42.1	43.8	-0.214E-05
37976.	685.	-30.2	42.5	44.1	-0.227E-05
37977.	683.	-32.2	43.1	44.6	-0.347E-05
37978.	685.	-34.0	43.9	45.3	-0.147E-05
37979.	685.	-35.5	44.7	46.2	-0.263E-05
37980.	684.	-36.8	45.7	47.3	-0.174E-05
37981.	685.	-37.8	46.8	48.6	-0.200E-05
37982.	684.	-38.4	47.8	49.9	-0.254E-05
37983.	684.	-38.8	48.9	51.5	-0.240E-05

Table 8 (cont.)

## RELATIVE POSITIONS OF THE SUN AND THE PERIGEE OF SATELLITE 1961 DELTA 1

MJD	Z	$\phi$	$\psi$	D.R.A.	$\dot{P}$
37984.	683.	-38.8	49.9	53.0	-0.267E-05
37985.	683.	-38.5	50.8	54.4	-0.240E-05
37986.	681.	-37.9	51.8	55.9	-0.214E-05
37987.	680.	-37.0	52.6	57.2	-0.227E-05
37988.	674.	-35.7	53.5	58.5	-0.200E-05
37989.	672.	-34.2	54.1	59.4	-0.294E-05
37990.	676.	-32.5	54.3	59.7	-0.200E-05
37991.	675.	-30.4	55.1	60.6	-0.307E-05
37992.	674.	-28.0	55.8	61.2	-0.240E-05
37993.	672.	-26.0	55.4	60.6	-0.160E-05
37994.	671.	-23.5	55.6	60.4	-0.267E-05
37995.	669.	-20.9	55.7	60.1	-0.160E-05
37996.	667.	-18.2	55.8	59.5	-0.214E-05
37997.	665.	-15.3	55.9	58.9	-0.210E-05
37998.	663.	-12.5	56.1	58.2	-0.200E-05
37999.	662.	-9.5	56.2	57.3	-0.240E-05
38000.	661.	-6.5	56.5	56.4	-0.227E-05
38001.	660.	-3.5	56.8	55.4	-0.214E-05
38002.	658.	-0.5	57.2	54.4	-0.213E-05
38003.	657.	2.6	57.7	53.4	-0.280E-05
38004.	656.	5.6	58.4	52.4	-0.217E-05
38005.	656.	8.6	59.2	51.5	-0.243E-05
38006.	656.	11.5	60.2	50.6	-0.240E-05

Table 8 (cont.)

## RELATIVE POSITIONS OF THE SUN AND THE PERIGEE OF SATELLITE 1961 DELTA 1

MJD	Z	$\Psi$	$\dot{\Psi}$	D.R.A.	$\dot{P}$
38007	655.	14.4	61.3	49.7	-0.253E-05
38008	654.	17.3	62.5	49.0	-0.227E-05
38009	652.	20.0	63.8	48.4	-0.240E-05
38010	652.	22.7	65.3	48.0	-0.267E-05
38011	653.	25.2	66.8	47.6	-0.307E-05
38012	652.	27.5	68.4	47.5	-0.240E-05
38013	651.	29.8	70.0	47.6	-0.263E-05
38014	651.	31.8	71.6	47.9	-0.200E-05
38015	650.	33.6	73.2	48.4	-0.227E-05
38016	650.	35.2	74.8	49.1	-0.293E-05
38017	650.	36.5	76.2	50.0	-0.253E-05
38018	649.	37.6	77.6	51.0	-0.280E-05
38019	648.	38.3	78.8	52.3	-0.227E-05
38020	648.	38.7	79.9	53.6	-0.213E-05
38021	647.	38.8	80.7	54.9	-0.185E-05
38022	646.	38.6	81.4	56.2	-0.213E-05
38023	645.	38.1	81.8	57.5	-0.160E-05
38024	644.	37.3	82.0	58.7	-0.173E-05
38025	643.	36.1	81.9	59.7	-0.164E-05
38026	643.	34.7	81.6	60.5	-0.533E-06
38027	642.	33.1	81.1	61.2	-0.120E-05
38028	640.	31.2	80.2	61.6	-0.533E-06

Satellite 1962 Alpha Epsilon 1 (Telstar)

Maria Gutierrez

I. SAO smoothed elements

The following elements are based on 263 observations and are valid for the period July 12 through July 31, 1962.

$$T_o = 37866.0 \text{ MJD}$$

$$\omega = (186^\circ 059 \pm 2) + (1^\circ 9865 \pm 3)t - 327 \times 10^{-4}t^2 + 1142 \cos \omega$$

$$\Omega = (183^\circ 8848 \pm 8) - (1^\circ 8584 \pm 1)t - 362 \times 10^{-5}t^2 + 0145 \cos \omega$$

$$i = (44^\circ 7923 \pm 5) - 625 \times 10^{-4}t - 0077 \sin \omega$$

$$e = (.242042 \pm 4) - .589 \times 10^{-5}t + .0005183 \sin \omega$$

$$M = (.024996 \pm 3) + (9.1261282 \pm 6)t - (.84 \pm 27) \times 10^{-7}t^2 - (.41 \pm 5) \times 10^{-7}t^3 \\ - .0003171 \cos \omega$$

Standard error of one observation:  $\sigma = \pm 1.15$ .

The following elements are based on 149 observations and are valid for the period July 31 through August 31, 1962.

$$T_o = 37890.0 \text{ MJD}$$

$$\omega = (233^\circ 761 \pm 5) + (1^\circ 9828 \pm 5)t - 327 \times 10^{-4}t^2 + 1142 \cos \omega$$

$$\Omega = (139^\circ 281 \pm 2) - (1^\circ 8584 \pm 3)t - 362 \times 10^{-5}t^2 + 0145 \cos \omega$$

$$i = (44^\circ 799 \pm 1) - 625 \times 10^{-4}t - 0077 \sin \omega$$

$$e = (.24226 \pm 1) - .589 \times 10^{-5}t + .0005183 \sin \omega$$

$$M = (.05183 \pm 1) + (9.1261182 \pm 9)t - (.43 \pm 3) \times 10^{-6}t^2 + (.23 \pm 3) \times 10^{-7}t^3 \\ - .0003171 \cos \omega$$

Standard error of one observation:  $\sigma = \pm 1.55$ .

The following elements are based on 383 observations and are valid for the period August 3 through September 30, 1962.

$$\begin{aligned}
 T_0 &= 37922.0 \text{ MJD} \\
 \omega &= (297^\circ 2971 \pm 3) + (1^\circ 98605 \pm 3)t - .327 \times 10^{-4}t^2 + .1142 \cos \omega \\
 \Omega &= (79^\circ 7892 \pm 1) - (1^\circ 859078 \pm 9)t - .362 \times 10^{-5}t^2 + .0145 \cos \omega \\
 i &= (44^\circ 80081 \pm 9) - .625 \times 10^{-4}t - .0077 \sin \omega \\
 e &= (.2423836 \pm 8) - .589 \times 10^{-5}t + .0005183 \sin \omega \\
 M &= (.0872908 \pm 7) + (9.1260964 \pm 1)t - (.302 \pm 2) \times 10^{-6}t^2 + (.284 \pm 4) \times 10^{-7}t^3 \\
 &\quad - .0003171 \cos \omega
 \end{aligned}$$

Standard error of one observation:  $\sigma = \pm 2.05$ .

The following elements are based on 273 observations and are valid for the period September 30 through October 31, 1962.

$$\begin{aligned}
 T_0 &= 37952.0 \text{ MJD} \\
 \omega &= (356^\circ 904 \pm 3) + (1^\circ 9870 \pm 4)t - .327 \times 10^{-4}t^2 + .1142 \cos \omega \\
 \Omega &= (24^\circ 015 \pm 1) - (1^\circ 8590 \pm 1)t - .362 \times 10^{-5}t^2 + .0145 \cos \omega \\
 i &= (44^\circ 8091 \pm 7) - .625 \times 10^{-4}t - .0077 \sin \omega \\
 e &= (.242332 \pm 4) - .589 \times 10^{-5}t + .0005183 \sin \omega \\
 M &= (.870108 \pm 7) + (9.1260904 \pm 8)t + (.43 \pm 13) \times 10^{-7}t^2 + (.14 \pm 2) \times 10^{-7}t^3 \\
 &\quad - .0003171 \cos \omega
 \end{aligned}$$

Standard error of one observation:  $\sigma = \pm 1.38$ .

The following elements are based on 229 observations and are valid for the period October 31 through November 30, 1962.

$$\begin{aligned}
 T_0 &= 37984.0 \text{ MJD} \\
 \omega &= (60^\circ 472 \pm 4) + (1^\circ 9868 \pm 3)t - .327 \times 10^{-4}t^2 + .1142 \cos \omega \\
 \Omega &= (324^\circ 534 \pm 1) - (1^\circ 8593 \pm 1)t - .362 \times 10^{-5}t^2 + .0145 \cos \omega \\
 i &= (44^\circ 7979 \pm 5) - .625 \times 10^{-4}t - .0077 \sin \omega \\
 e &= (.242335 \pm 5) - .589 \times 10^{-5}t + .0005183 \sin \omega \\
 M &= (.905232 \pm 7) + (9.1261068 \pm 7)t + (.36 \pm 1) \times 10^{-6}t^2 - (.20 \pm 17) \times 10^{-8}t^3 \\
 &\quad - .0003171 \cos \omega
 \end{aligned}$$

Standard error of one observation:  $\sigma = \pm 2.65$ .

The following elements are based on 121 observations and are valid for the period November 30 through December 31, 1962.

$$T_o = 38012.0 \text{ MJD}$$

$$\omega = (116^\circ 072 \pm 4) + (1^\circ 9859 \pm 4)t - .327 \times 10^{-4}t^2 + .1142 \cos \omega$$

$$\Omega = (272^\circ 482 \pm 2) - (1^\circ 8587 \pm 2)t - .364 \times 10^{-5}t^2 + .0145 \cos \omega$$

$$i = (44^\circ 795 \pm 1) - .625 \times 10^{-4}t - .0077 \sin \omega$$

$$e = (.242206 \pm 9) - .589 \times 10^{-5}t + .0005183 \sin \omega$$

$$M = (.436528 \pm 7) + (9.1261296 \pm 8)t + (.47 \pm 2) \times 10^{-6}t^2 - (.17 \pm 3) \times 10^{-7}t^3$$

$$- .0003171 \cos \omega$$

Standard error of one observation:  $\sigma = \pm 2^\circ 40,$

$\frac{T}{(MJD)}$	$\omega$	$\Omega$	$i$	$e$	$M$	$n$	$n^{1/2}$	$q$	$N$	$D$	$C$
37858.0	169.93 2	198.7117 8	44.784 4	.24198 4	.01657 4	9.125933 4	.84E-4 3	7.331728	108	6	1.30
37862.0	177.993 2	191.3029 9	44.7907 6	.242083 5	.520810 4	9.126119 1	.13E-5 3	7.330643	125	6	1.19
37866.0	185.956 3	183.870 1	44.7936 7	.241999 6	.025299 6	9.126113 1	-.15E-5 5	7.331460	88	6	1.18
37870.0	193.907 3	176.431 2	44.797 1	.24194 1	.529800 7	9.126109 1	.6E-6 7	7.332050	66	6	1.23
37874.0	201.841 9	169.003 2	44.794 2	.24181 2	.03429 2	9.126108 1	.1E-6 9	7.333325	34	6	1.46
37878.0	209.821	161.564 5	44.800 3	.24188 3	.53871 2	9.126110 2	.25E-5 9	7.332578	26	6	1.56
37882.0	217.761 2	154.138 1	44.8044 8	.241842 6	.043189 4	9.126105 1	-.1E-6 9	7.332982	38	6	1.28
37886.0	225.719 2	146.7021 8	44.8033 5	.241818 4	.547645 3	9.126098 1	-.34E-5 4	7.333221	69	6	1.26
37890.0	233.642 2	139.2692 4	44.8050 5	.241745 3	.052148 4	9.126089 1	.4E-5 3	7.333934	61	6	1.34
37894.0	241.614 1	131.8428 7	44.8091 4	.241733 3	.556480 2	9.126092 1	.14E-5 3	7.334042	72	6	1.33
37898.0	249.5932 9	124.4058 3	44.8054 2	.241823 2	.060876 2	9.126099 1	-.35E-5 2	7.333175	53	6	1.19
37902.0	257.5505 8	116.9606 3	44.8024 3	.241841 4	.565288 3	9.126090 1	.14E-5 3	7.333001	69	6	1.44
37906.0	265.5036 7	109.5308 2	44.8159 2	.241844 3	.069669 2	9.126085 1	-.5E-5 2	7.332973	75	6	1.37
37910.0	273.4693 5	102.1014 1	44.8041 2	.241824 2	.574015 1	9.126088 1	.33E-5 2	7.333163	54	6	1.26
37914.0	281.423 2	94.6660 8	44.8022 5	.241852 4	.078422 3	9.126086 1	-.14E-5 2	7.332896	79	6	1.34
37918.0	289.380 1	87.2319 6	44.8052 5	.241871 4	.582788 3	9.125083 1	.4E-6 3	7.332712	79	6	1.34
37922.0	297.345 5	79.7920 3	44.8026 2	.241920 2	.087149 2	9.126084 1	.9E-6 3	7.332243	81	6	1.32
37926.0	305.3108 5	72.3567 2	44.8048 2	.241945 2	.594496 1	9.126080 1	-.25E-5 2	7.332005	99	6	1.30
37930.0	313.2538 8	64.9248 2	44.8085 2	.241997 5	.095878 4	9.126084 1	-.12E-5 3	7.331499	78	6	1.36
37934.0	321.205 2	57.4873 4	44.8036 4	.242043 5	.600229 3	9.126078 1	.12E-5 3	7.331058	67	6	1.38

T (MJD)	$\omega$	$\Omega$	$i$	$e$	M	n	$n'/2$	q	N	D	$\sigma$
37938.0	329.1684 7	50.0551 2	44.8076 2	*242143 3	*104554 2	9.126092 1	*11E-5 3	7.330084	82	6	1.35
37942.0	337.141 1	42.6164 8	44.8049 4	*242102 6	*608903 3	9.126095 1	-.8E-6 3	7.330473	98	6	1.42
37946.0	345.073 1	35.1858 6	44.8056 5	*242202 4	*113309 4	9.126091 1	-.19E-5 4	7.329511	99	6	1.44
37950.0	353.037 2	27.751 1	44.8078 6	*242262 5	*617609 5	9.126085 1	*4E-6 3	7.328928	94	6	1.43
37954.0	.990 1	20.3126 6	44.8068 3	*242351 4	*121945 2	9.126094 1	*8E-6 3	7.328071	87	6	1.36
37958.0	8.921 1	12.8797 3	44.8052 2	*242378 2	*626370 2	9.126105 1	*11E-5 3	7.327804	66	6	1.38
37962.0	16.876 8	5.437 3	44.805 2	*24247 1	*13075 2	9.126101 1	-.5E-6 6	7.326914	39	6	1.44
37966.0	24.829 6	358.000 2	44.808 2	*242550 7	*63513 1	9.126103 1	-.13E-5 7	7.326140	54	6	1.37
37970.0	32.766 7	350.565 2	44.804 2	*242598 9	*13953 1	9.126106 1	*9E-6 6	7.325670	52	6	1.43
37974.0	40.70 1	343.133 3	44.803 2	*24264 1	*64395 2	9.126111 1	*7E-6 9	7.325267	42	6	1.40
37978.0	48.64 1	335.694 4	44.800 3	*24269 2	*14838 3	9.126118 2	*13E-5 9	7.324752	31	6	1.39
37982.0	56.58 1	328.257 2	44.799 2	*24277 1	*65282 2	9.126121 2	*8E-6 7	7.324012	34	6	1.39
37986.0	64.500 7	320.822 2	44.797 1	*24277 1	*15731 1	9.126123 1	*3E-6 6	7.324005	50	6	1.41
37990.0	72.421 9	313.384 2	44.794 2	*24282 1	*66179 2	9.126122 1	*23E-5 8	7.323502	52	6	1.51
37994.0	80.3600 8	305.9436 6	44.7886 4	*242869 6	*166265 3	9.126124 1	-.11E-5 4	7.323036	51	6	1.38
37998.0	88.2797 9	298.5016 6	44.7871 5	*242814 8	*670795 3	9.126138 1	*14E-5 4	7.323564	55	6	1.45
38002.0	96.196 4	291.064 2	44.787 1	*24279 1	*175349 8	9.126136 2	-.1E-5 9	7.323837	34	6	1.49
38006.0	104.11 2	283.633 5	44.788 3	*24278 2	*67989 3	9.126134 2	-.11E-5 9	7.323895	21	6	1.42
38010.0	112.07 2	276.193 7	44.792 4	*24267 3	*18434 4	9.126139 2	*3E-5 1	7.324923	24	6	1.56
38014.0	119.96 2	268.761 7	44.788 3	*24262 3	*68897 4	9.126159 2	*4E-5 1	7.325395	26	6	1.47
38018.0	127.91 2	261.323 5	44.788 3	*24258 2	*19355 3	9.126149 2	-.1E-5 1	7.325853	21	6	1.55
38022.0	135.87 1	253.890 6	44.789 3	*24249 3	*69804 3	9.126142 4	*1E-5 4	7.326768	12	6	1.49
38026.0	143.798 9	246.450 5	44.793 2	*24236 2	*20258 2	9.126151 2	*26E-5 9	7.327969	22	6	1.45

Table 9

RELATIVE POSITIONS OF THE SUN AND THE PERIGEE OF SATELLITE 1962 ALPHA EPSILON 1

MJD	Z	$\varphi$	$\psi$	D.R.A.	$\dot{P}$
PERIGEE IN SUNLIGHT					
37858.	954.	7.1	96.8	259.7	-0.202E-05
37862.	952.	1.4	104.3	254.0	-0.312E-07
37866.	953.	-4.2	111.8	248.3	0.360E-07
37870.	954.	-9.7	119.0	242.6	-0.144E-07
PERIGEE IN EARTH SHADOW					
37874.	956.	-15.2	125.5	237.1	-0.240E-08
37878.	957.	-20.5	131.0	232.0	-0.600E-07
37882.	959.	-25.6	135.2	227.4	0.240E-08
37886.	960.	-30.3	137.8	223.4	0.816E-07
37890.	962.	-34.6	138.8	220.1	-0.961E-07
37894.	964.	-38.3	138.4	217.7	-0.336E-07
37898.	964.	-41.3	136.9	216.1	0.840E-07
37902.	965.	-43.5	135.1	215.4	-0.336E-07
37906.	965.	-44.6	133.3	215.3	0.120E-06
37910.	965.	-44.7	132.0	215.4	-0.792E-07
37914.	965.	-43.7	131.5	215.4	0.336E-07
37918.	964.	-41.7	131.8	214.8	-0.961E-08
37922.	962.	-38.8	133.2	213.5	-0.216E-07
37926.	961.	-35.1	135.7	211.4	0.600E-07
37930.	959.	-30.9	139.2	208.4	0.288E-07
37934.	957.	-26.2	143.6	204.7	-0.288E-07

Table 9 (cont.)

RELATIVE POSITIONS OF THE SUN AND THE PERIGEE OF SATELLITE 1962 ALPHA EPSILON 1

MJD	Z	$\Phi$	$\Psi$	D.R.A.	$\dot{P}$
37938.	954.	-21.2	148.7	200.4	-0.264E-07
37942.	954.	-15.9	154.5	195.6	0.192E-07
37946.	952.	-10.5	160.5	190.5	0.456E-07
37950.	951.	-4.9	166.6	185.1	-0.961E-08
37954.	950.	0.7	171.7	179.6	-0.192E-07
37958.	950.	6.3	172.8	174.1	-0.264E-07
37962.	949.	11.8	168.9	168.6	0.120E-07
37966.	950.	17.2	163.5	163.4	0.312E-07
37970.	950.	22.4	158.1	158.4	-0.216E-07
37974.	951.	27.4	153.2	153.9	-0.168E-07
37978.	952.	31.9	148.9	149.9	-0.312E-07
37982.	953.	36.0	145.5	146.6	-0.192E-07
37986.	954.	39.5	143.0	144.1	-0.720E-08
37990.	955.	42.2	141.3	142.3	-0.552E-07
37994.	955.	44.0	140.5	141.3	0.264E-07
37998.	956.	44.8	140.2	140.6	-0.336E-07
38002.	956.	44.5	140.4	139.9	0.240E-07
38006.	956.	43.1	140.5	139.0	0.264E-07
38010.	956.	40.8	140.2	137.4	-0.720E-07
38014.	955.	37.6	139.0	134.9	-0.961E-07
38018.	954.	33.8	136.6	131.6	0.240E-07
38022.	954.	29.4	133.0	127.5	-0.240E-07
38026.	953.	24.6	128.0	122.7	-0.624E-07

Satellite 1962 Beta Lambda 1(Explorer XV)

Joan Weingarten

I. SAO smoothed elements

The following elements are based on 140 observations and are valid for the period October 27 through November 11, 1962.

$$T_o = 37972.0 \text{ MJD}$$

$$\omega = (149^\circ 116 \pm 5) + (1^\circ 750 \pm 1)t - .0270 \cos \omega$$

$$\Omega = (209^\circ 384 \pm 5) - (0^\circ 944 \pm 1)t + .0636 \cos \omega$$

$$i = (18^\circ 020 \pm 1) - .0245 \sin \omega$$

$$e = (.563779 \pm 7) - (.18 \pm 1) \times 10^{-4} t + .0001680 \sin \omega$$

$$M = (.055400 \pm 4) + (4.5663736 \pm 8)t + (.5244 \pm 7) \times 10^{-4} t^2 - (.10 \pm 2) \times 10^{-6} t^3 \\ - .3910 \times 10^{-4} \cos \omega$$

Standard error of one observation:  $\sigma = \pm 2.90$ .

The following elements are based on 103 observations and are valid for the period November 11 through November 26, 1962.

$$T_o = 37988.0 \text{ MJD}$$

$$\omega = (177^\circ 108 \pm 4) + (1^\circ 7528 \pm 8)t - .0270 \cos \omega$$

$$\Omega = (194^\circ 293 \pm 4) - (0^\circ 9453 \pm 8)t + .0636 \cos \omega$$

$$i = (18^\circ 005 \pm 1) - .0245 \sin \omega$$

$$e = (.563438 \pm 6) - (.57 \pm 12) \times 10^{-5} t + .0001680 \sin \omega$$

$$M = (.130065 \pm 3) + (4.5678895 \pm 6)t + (.4046 \pm 7) \times 10^{-4} t^2 - (.28 \pm 1) \times 10^{-6} t^3 \\ - .3910 \times 10^{-4} \cos \omega$$

Standard error of one observation:  $\sigma = \pm 1.80$ .

c

The following elements are based on 46 observations and are valid for the period November 26 through December 11, 1962.

$$T_o = 38002.0 \text{ MJD}$$

$$\omega = (201^\circ 58 \pm 2) + (1^\circ 748 \pm 3)t - .0270 \cos \omega$$

$$\Omega = (181^\circ 06 \pm 2) - (0^\circ 945 \pm 3)t + .0636 \cos \omega$$

$$i = (17^\circ 994 \pm 2) - .0245 \sin \omega$$

$$e = (.56341 \pm 7) + (.11 \pm 11) \times 10^{-4} t + .0001680 \sin \omega$$

$$M = (.087612 \pm 8) + (4.568818 \pm 2)t + (.271 \pm 2) \times 10^{-4} t^2 - (.58 \pm 39) \times 10^{-7} t^3 \\ - .3910 \times 10^{-4} \cos \omega$$

Standard error of one observation:  $\sigma = \pm 1^\circ 38$ .

The following elements are based on 16 observations and are valid for the period December 11 through December 20, 1962.

$$T_o = 38014.0 \text{ MJD}$$

$$\omega = (225^\circ 0 \pm 2) + (1^\circ 46 \pm 7)t - .0270 \cos \omega$$

$$\Omega = (168^\circ 9 \pm 1) - (0^\circ 91 \pm 2)t + .0636 \cos \omega$$

$$i = (18^\circ 13 \pm 3) - .0245 \sin \omega$$

$$e = (.5567 \pm 6) + (.0010 \pm 3)t + .0001680 \sin \omega$$

$$M = (.91714 \pm 5) + (4.56964 \pm 2)t + (.27 \pm 2) \times 10^{-4} t^2 - .3910 \times 10^{-4} \cos \omega$$

Standard error of one observation:  $\sigma = \pm 4^\circ 13$ .

$T$ (MJD)	$\omega$	$\Omega$	$i$	$e$	$M$	$n$	$n'/2$	$q$	$N$	$D$	$\sigma$
37968.0	142.128 9	213.118 9	18.005 3	.56390 1	*790787 5	4.565954 2	*56E-4 1	6.692267	63	8	.56
37970.0	145.61 1	211.24 1	18.008 3	.56388 2	*922925 5	4.566160 3	*518E-4 4	6.692501	47	8	.58
37972.0	149.12 1	209.37 1	18.015 3	.56382 2	*05432 7	4.566187 3	*524E-4 6	6.693187	44	8	.62
37974.0	152.615 8	207.478 8	18.011 2	.56380 1	*188379 4	4.566577 1	*530E-4 2	6.693183	68	8	.59
37976.0	156.124 7	205.577 7	18.013 2	.563770 9	*321750 4	4.565797 2	*516E-4 3	6.693484	78	8	.60
37978.0	159.636 6	203.670 5	18.013 2	.563717 6	*455540 2	4.566993 1	*480E-4 2	6.694114	83	8	.57
37980.0	163.132 7	201.779 7	18.008 1	.563614 7	*589719 2	4.567184 1	*480E-4 3	6.695503	80	8	.51
37982.0	166.644 9	199.882 8	18.006 2	.563529 9	*724269 3	4.567365 2	*458E-4 3	6.696625	62	8	.49
37984.0	170.14 1	198.002 9	18.003 2	.563477 8	*859190 5	4.567553 1	*466E-4 4	6.697249	50	8	.45
37986.0	173.63 1	196.12 1	18.003 2	.56349 1	*994503 5	4.567730 2	*411E-4 3	6.696931	45	8	.43
37988.0	177.124 8	194.230 7	18.002 2	.563455 7	*130132 4	4.567890 2	*367E-4 3	6.697251	43	8	.37
37990.0	180.628 6	192.339 6	18.001 2	.563418 7	*266059 3	4.568039 1	*392E-4 3	6.697677	54	8	.41
37992.0	184.137 4	190.443 4	18.001 2	.563390 7	*402296 3	4.568203 1	*402E-4 2	6.697949	59	8	.44
37994.0	187.644 5	188.554 5	18.002 2	.563345 9	*538862 2	4.568366 2	*344E-4 5	6.698481	52	8	.51
37996.0	191.132 7	186.665 8	18.000 2	.56327 1	*675728 4	4.568497 2	*322E-4 6	6.699522	43	8	.49
37998.0	194.61 2	184.79 2	17.997 3	.56320 6	*812842 9	4.568609 3	*283E-4 6	6.700523	30	8	.56
38000.0	198.15 2	182.87 2	17.994 3	.56306 6	*950164 8	4.568703 2	*250E-4 5	6.702472	21	8	.39
38002.0	201.67 2	180.96 2	18.001 3	.56325 9	*087650 9	4.568814 3	*272E-4 4	6.699574	20	8	.40
38004.0	205.17 2	179.08 2	18.002 3	.56323 8	*225378 8	4.568915 3	*280E-4 4	6.699751	21	8	.39
38006.0	208.65 4	177.21 3	18.003 3	.56331 1	*36332 1	4.569029 5	*277E-4 7	6.698877	18	8	.38
38008.0	212.32 8	175.27 4	18.006 4	.5628 3	*50147 2	4.569138 7	*306E-4 8	6.706673	13	8	.36
38010.0	217.5 2	172.7 2	18.10 3	.5584 6	*63959 7	4.56927 2	*40E-4 6	6.772930	10	8	1.76
38012.0	222.0 8	170.5 2	18.16 3	.555 3	*7782 3	4.5694 4	*3E-4 1	6.826353	8	8	1.45
38014.0	225.1 3	168.7 1	18.14 4	.556 1	*9173 1	4.56963 5	*23E-4 3	6.810764	12	8	1.45
38016.0	227.9 1	166.96 7	18.14 2	.5585 5	*05667 4	4.56969 1	*23E-4 2	6.771631	13	8	.86

Table 10

## RELATIVE POSITIONS OF THE SUN AND THE PERIGEE OF SATELLITE 1962 BETA LAMBDA 1

MJD	$\gamma$	$\Phi$	$\psi$	D.R.A.	$\dot{P}$
PERIGEE IN EARTH SHADOW					
37968.	315.	10.9	142.7	141.9	-0.537E-05
37970.	315.	10.1	142.1	141.5	-0.497E-05
37972.	315.	9.1	141.5	141.1	-0.503E-05
37974.	315.	8.2	140.8	140.6	-0.508E-05
37976.	315.	7.2	140.0	140.1	-0.495E-05
37978.	316.	6.2	139.1	139.6	-0.460E-05
37980.	317.	5.1	138.1	139.0	-0.460E-05
37982.	318.	4.1	137.0	138.4	-0.439E-05
37984.	319.	3.0	136.0	137.9	-0.447E-05
37986.	319.	2.0	134.8	137.2	-0.394E-05
37988.	319.	0.9	133.6	136.6	-0.352E-05
37990.	319.	-0.2	132.4	135.9	-0.376E-05
37992.	320.	-1.3	131.1	135.3	-0.385E-05
37994.	320.	-2.4	129.9	134.6	-0.330E-05
37996.	321.	-3.4	128.6	133.9	-0.309E-05
37998.	322.	-4.5	127.3	133.2	-0.271E-05
38000.	324.	-5.5	126.1	132.5	-0.240E-05
38002.	321.	-6.6	124.8	131.8	-0.261E-05
38004.	322.	-7.6	123.6	131.2	-0.268E-05
38006.	321.	-8.5	122.4	130.5	-0.265E-05
38008.	329.	-9.5	121.3	129.9	-0.293E-05
38010.	395.	-10.9	120.7	130.2	-0.383E-05
38012.	449.	-12.0	119.9	130.3	-0.287E-05
38014.	433.	-12.7	118.8	129.4	-0.220E-05
38016.	394.	-13.4	117.4	128.2	-0.220E-05

Satellite 1962 Beta Mu 1 (Anna 1B)

Joan Weingarten

I. SAO smoothed elements

The following elements are based on 358 observations and are valid for the period October 31 through November 30, 1962.

$$T_o = 37982.0 \text{ MJD}$$

$$\omega = (247^\circ 67 \pm 5) + (2^\circ 976 \pm 5)t + 6^\circ 6720 \cos \omega$$

$$\Omega = (5^\circ 0443 \pm 4) - (3^\circ 60892 \pm 4)t + 00008 \cos \omega$$

$$i = (50^\circ 1429 \pm 2) - 00002 \sin \omega$$

$$e = (.007061 \pm 3) - (.39 \pm 3) \times 10^{-5}t + .0007540 \sin \omega$$

$$M = (.8174 \pm 1) + (13.34477 \pm 1)t - (.130 \pm 1) \times 10^{-5}t^2 + (.65 \pm 1) \times 10^{-7}t^3 \\ - .017014 \cos \omega$$

Standard error of one observation:  $\sigma = \pm 1^\circ 20$ .

The following elements are based on 578 observations and are valid for the period November 30 through December 31, 1962.

$$T_o = 38012.0 \text{ MJD}$$

$$\omega = (336^\circ 90 \pm 5) + (2^\circ 954 \pm 5)t + 6^\circ 6720 \cos \omega$$

$$\Omega = (256^\circ 7761 \pm 4) - (3^\circ 60886 \pm 5)t + 00008 \cos \omega$$

$$i = (50^\circ 1414 \pm 4) - 00002 \sin \omega$$

$$e = (.007082 \pm 3) + (.34 \pm 4) \times 10^{-5}t + .0007540 \sin \omega$$

$$M = (.1607 \pm 1) + (13.34486 \pm 2)t + (.147 \pm 1) \times 10^{-5}t^2 + (.21 \pm 1) \times 10^{-7}t^3 \\ - .017014 \cos \omega$$

Standard error of one observation:  $\sigma = \pm 1^\circ 45$ .

III. SAO mean elements - Satellite 1962 Beta Mu 1

2 November - 28 December 1962

T (MJD)	$\omega$	$\Omega$	i	e	M	n	$n^{1/2}$	q	N	D	$\sigma$
37970.0	206.47 4	48.3481 6	50.1435 2	.006671 3	.6938 1	13.344531 1	-.82E-5 7	7.457806	103	4	.34
37974.0	219.19 4	33.9173 9	50.1448 7	.006558 8	.0710 1	13.344367 2	.2E-5 1	7.458715	76	4	.50
37978.0	230.8 2	19.475 2	50.144 2	.00641 2	.4510 6	13.344288 3	.34E-4 3	7.459860	50	4	.65
37982.0											
37986.0											
37990.0	271.7 2	336.174 1	50.144 1	.006300 8	.5749 5	13.344117 2	-.3E-5 2	7.460748	60	4	.45
37994.0	285.2 3	321.737 2	50.146 2	.00630 1	.9499 8	13.344146 2	.2E-5 2	7.460734	30	4	.46
37998.0	298.2 3	307.299 2	50.144 2	.00638 1	.3261 7	13.344223 3	.1E-5 2	7.460131	31	4	.49
38002.0	311.3 2	292.866 2	50.142 1	.00643 1	.7021 5	13.344327 2	-.1E-5 2	7.459718	76	4	.51
38006.0	324.1 2	278.430 1	50.144 1	.00658	.0791 4	13.344460 2	.4E-5 1	7.458488	93	4	.61
38010.0	336.5 2	263.992 2	50.140 1	.00671 1	.4571 6	13.344615 2	.2E-5 2	7.457472	40	4	.55
38014.0	349.3 1	249.561 1	50.1393 9	.006858 7	.8338 3	13.344790 2	-.5E-5 2	7.456308	96	4	.49
38018.0	1.2 1	235.1225 9	50.1411 7	.007036 6	.2131 3	13.344972 1	.1E-5 1	7.454905	122	4	.53
38022.0	13.1 2	220.688 2	50.141 2	.00719 1	.5924 6	13.345164 2	.2E-5 2	7.453696	65	4	.56
38026.0	24.9 2	206.258 2	50.142 2	.00733 1	.9719 5	13.345347 2	-.1E-5 1	7.452593	61	4	.46

Table 11

RELATIVE POSITIONS OF THE SUN AND THE PERIGEE OF SATELLITE 1962 BETA MU 1

MJD	Z	$\Phi$	$\Psi$	D.R.A.	$\dot{P}$
PERIGEE IN SUNLIGHT					
37970.	1082.	-20.0	28.5	29.3	0.921E-07
37974.	1085.	-29.0	23.3	20.9	-0.225E-07
37978.	1089.	-36.5	22.7	13.0	-0.382E-06
37990.	1095.	-50.1	31.6	11.8	0.337E-07
37994.	1094.	-47.8	29.1	13.5	-0.225E-07
37998.	1092.	-42.6	23.2	11.7	-0.112E-07
38002.	1088.	-35.2	14.4	6.9	0.112E-07
38006.	1084.	-26.8	4.1	359.4	-0.449E-07
38010.	1081.	-17.8	10.8	349.9	-0.225E-07
38014.	1078.	-8.2	24.6	339.7	0.562E-07
38018.	1077.	0.9	39.1	328.5	-0.112E-07
38022.	1076.	10.0	53.5	317.3	-0.225E-07
38026.	1076.	18.9	67.1	306.5	0.112E-07



## NOTICE

This series of Special Reports was instituted under the supervision of Dr. F. L. Whipple, Director of the Astrophysical Observatory of the Smithsonian Institution, shortly after the launching of the first artificial earth satellite on October 4, 1957. Contributions come from the Staff of the Observatory. First issued to ensure the immediate dissemination of data for satellite tracking, the Reports have continued to provide a rapid distribution of catalogues of satellite observations, orbital information, and preliminary results of data analyses prior to formal publication in the appropriate journals.

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